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GRAND PALACE OF FINE ARTS, PARIS EXPOSITION.

THE main façade of the Grand Palais consists of a central portico having on either side a long colonnade. The appearance of the central peristyle will be seen in the photograph, which will give a good idea of the architectural style of the building. The pairs of columns upholding the roof give three entranceways, which have a corresponding door in the rear. The façade is ornamented with a number of fine groups by French artists. The colonnade proceeding on each side from the main peristyle has a number of figures, executed in stone, placed at intervals between the columns. Between the pairs of columns of the peristyle are upright figures, executed in marble, representing the different arts. The three main doors at the rear of the peristyle are of gilded ironwork; their design will be seen in the illustration. The rear façade of the building, of which a view is shown in the photograph, presents somewhat the same architectural *motifs;* the arrangement of the pilasters on either side of the arched doorway, and the various groups with which the façade is ornamented, give a rich and pleasing effect; the group at the top is of bronze, as are also those on each side of the doorway. On either side proceeds a colonnade, at the back of which is a frieze in enameled Sèvres tile of fine color.

The interior of the Grand Palais is divided into two main portions, consisting of a large main hall in the front part, joined by means of an intermediate portion to a circular rotunda, from which leads a gallery on either side. The illustrations show the appearance of the main hall, which

HALL OF STATUARY UNDER THE GREAT DOME.

PARIS EXPOSITION—MAIN ENTRANCE TO THE GRAND PALACE OF FINE ARTS.

gives the idea of great size and height. The curved roof of glass affords ample illumination of the interior. The lower floor is devoted to a splendid art collection in which all nations are represented; the different works are executed in marble, bronze or plaster. At the back of the great hall a stairway rises on each side to the second floor, which is in the form of a gallery extending entirely around the interior;

REAR FAÇADE, GRAND PALACE OF FINE ARTS.

it is divided into a great number of rooms which are filled with collections of paintings; each nation has several rooms allotted to it; the United States has six rooms, which contain a representative collection of the best American artists; Germany, England, and of course France, have all notable collections. The ground floor has a similar series of rooms around the interior, also filled with paintings; the works in the Grand Palais are all of the modern schools, those of the last century being included in the historic collection to which the Petit Palais is devoted.

The architecture of the main hall, which is built mainly of iron and glass, is not of a specially ornamental character; this is, however, compensated for in the construction of the rotunda in the rear of the building, which is a good specimen of modern French art. The general appearance of the rotunda will be seen in the illustration. It is noted especially for the richness of its ornamentation; it is circular in form, and surrounded by a series of square piers which uphold the vault. It is lighted from the top by an oval window. The piers are of white stone, carrying on the interior a facing of green marble. Upon this a bronze ornamentation runs from the top to bottom, giving an especially rich appearance owing to the contrast of the different materials and the artistic execution. Each of the piers is surmounted by a very handsome group which gives rise to a series of decorative *motifs* surrounding the arches and reaching to the top of the vault. At the height of the second story a gallery runs around the rotunda, having a bronze balustrade of rich design. Below is a corresponding gallery, raised above the floor level, to which access is given by a flight of ten steps on either side; here the balustrade is of stone, with a bronze group on either side of the stairway. The floor of the rotunda is of mosaic, finely executed in different patterns. The space is devoted to a collection of sculpture by French artists of the present century.

A series of galleries, above and below, open into the center of the rotunda; these are devoted mainly to collections of paintings which represent the earlier schools of the present century, including the works of Delacroix, Vernet, etc.

[Continued from SUPPLEMENT, No. 1293, page 20732.]

CHEMICAL AND TECHNICAL EDUCATION IN THE UNITED STATES.*

By Prof. C. F. CHANDLER, Ph.D., M.D., LL.D., D.Sc. Oxon.

BORAX.

WE have a considerable industry in borax and boric acid; in fact, we are the largest producers in the world of these substances. They are made from the colemanite of California, calcium borate, of which 34,068 tons were mined in 1899, and from the alkaline waters and efflorescences of some of the Western States.

MINOR PRODUCTS.

Bromine was manufactured to the extent of 433,033 lb. Some tungsten and ferro-tungsten were manufactured, as well as chromates and bichromates.

Bisulphide of carbon is manufactured at one or two points.

We have quite an industry in the manufacture of carbonate of magnesia and Epsom salts, the materials being either dolomite, or magnesite from California, or imported from the Mediterranean.

Carbonate of lithia is manufactured from the beautiful lepidolite of San Diego, California.

GLASS.

The abundance of sand and limestone of excellent quality in many localities in the United States has led to the building up of a great glass industry. Window glass, plate glass, and cut glass are very extensively manufactured, and recently in New York city, and in one or two other places, great success has attended the attempt to manufacture all kinds of fine-colored and opalescent art glass in the most elegant forms; especially noticeable is Favrile glass, manufactured by Louis Tiffany, a beautiful exhibit of which can be seen at the Paris Exposition.

CLAY WARES.

Very extensive deposits of clay of all kinds, from kaolin down to common brick clays, are found freely distributed throughout the United States, and large industries have grown up in connection with them. These are especially extensive in New Jersey in the neighborhood of Trenton. The value of the clay wares produced in the United States in 1899 is estimated at about $75,000,000.

CEMENT.

The cement industry is developing with great rapidity in the United States. There are now 40 factories producing Portland cement, and the product for 1900 will be nearly 6,000,000 barrels. The increase has been greatest in the Lehigh Valley region in Pennsylvania. The severe requirements of engineers and the introduction of testing laboratories for cements, and the employment of chemists at the works, has led to a great improvement in the quality, and consequently a much more general use of the American product. The new plants in the East employ the rotary kiln as giving the best results.

LIQUEFIED GASES.

The preparation of liquefied gases has reached considerable proportions in the United States. The industry began with liquid sulphurous acid for ice machines and disinfecting purposes. This was followed by the introduction of liquefied ammonia, which is now manufactured in very large quantities for ice machines, both for the large companies and for isolated plants in hotels and other establishments.

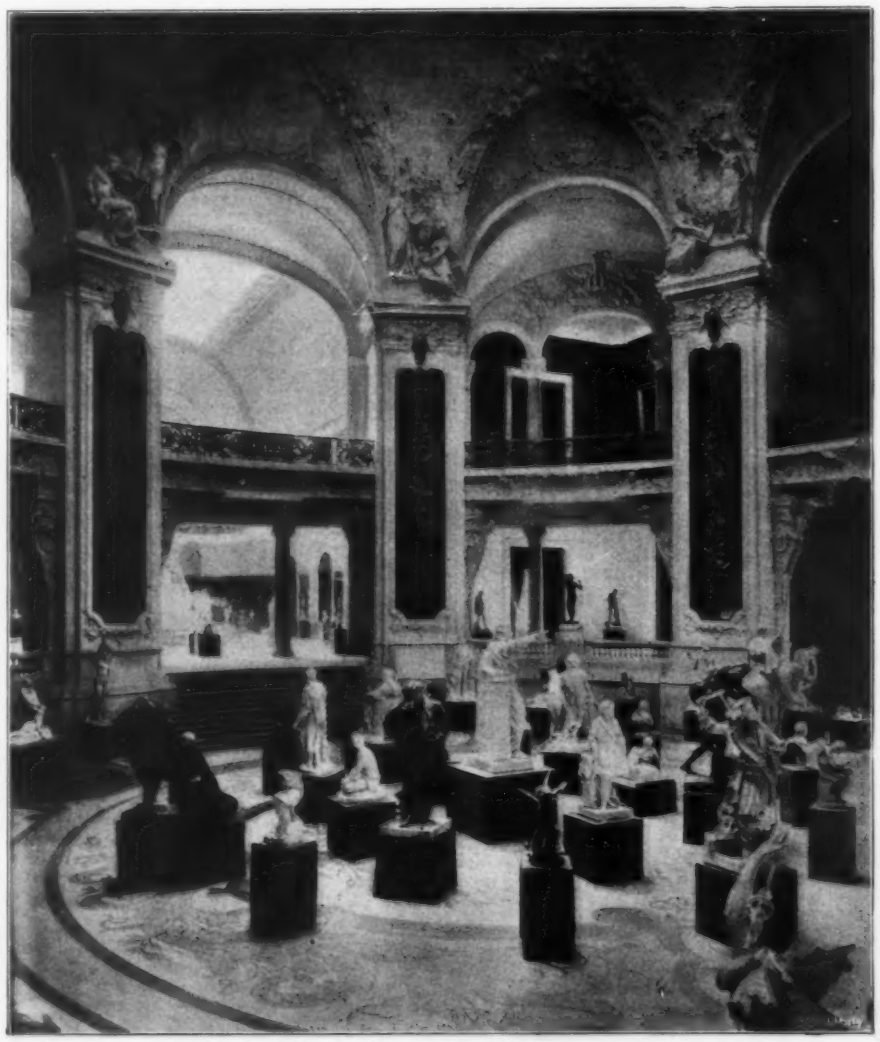
Liquefied carbonic acid is now a regular article of commerce, being made by several companies, and being supplied for the manufacture of aerated beverages, the charging of beer and other purposes.

Liquefied nitrous oxide was supplied for the use of dentists, but that has been given up on account of the limited quantities of the gas employed and the unnecessary danger involved in supplying it in the liquid state.

The greatest interest at the present time attaches to the liquefaction of air. The great success which has attended Prof. Dewar's efforts in the liquefaction of oxygen and air has led inventors in the United States to take up the subject, and machinery has been devised which is very efficient in accomplishing this liquefaction. The most notable experimenter in this direction is Charles E. Tripler, of New York, who has surprised us by the ease with which he liquefies air in large quantities. Unfortunately, the subject has developed just at present in the direction of stock companies. There are at least three different companies who advertise stock for sale, one of them with a capital of $10,000,000. This seems rather premature, as one can hardly say that any well-defined application of liquid air on a large scale has yet been worked out.

ICE.

The production of artificial cold economically by means of liquid ammonia has assumed enormous magnitude in the United States in recent years. The chief applications are for the cold storage warehouses, the fermenting rooms of the great breweries, and the manufacturers of artificial ice, the latter applications being particularly valuable in the southern portions of the country, but even in the Northern States the artificial ice competes successfully with the natural. A single example will sufficiently illustrate the advan-



THE ROTUNDA, GRAND PALACE OF FINE ARTS.

* Read at the nineteenth annual general meeting of the Society in London, in the theater of the Royal Institution, Albemarle Street, on Wednesday, July 18, 1900, Prof. C. F. Chandler, President of the Society, in the chair.

tages of the process. The small ice plant at Pelham, near New York city, which cost $25,000, turns out easily 18 tons of ice per day, and 20 tons if necessary. The ice is produced in rectangular blocks, weighing 300 pounds each, at a cost of 17 cents per block, or about 5 cents per 100 pounds, and can be delivered at private houses at about 40 cents per 100 pounds.

ELECTRO-CHEMISTRY.

Electro-chemistry is making great progress in the United States, particularly at Niagara Falls, where the Niagara Power Company and the Canal Company supply the necessary electricity. The industries which have established themselves there are devoted to the manufacture of aluminium, carborundum, artificial graphite, calcium carbide, potassium chlorate, phosphorus, spongy lead, caustic soda, bleaching powder, and metallic sodium.

ALUMINIUM.

The first electro-chemical enterprise to be established at Niagara Falls was that of the Pittsburg Reduction Company for the manufacture of aluminium. Aluminium is a subject in which I have always been deeply interested, having listened to Woehler's account of the discovery of aluminium, having been shown by Heinrich Rose the aluminium which he first extracted from cryolite, having known St. Clair Deville, who first manufactured the metal on a commercial scale, having been a warm friend of Castner, who by his cheap sodium process at one time monopolized the manufacture of aluminium, and being the intimate friend of Hall, whose electrolytic process now produces all the aluminium of commerce.

It was a remarkable fact, after all the attention that had been devoted to the subject of aluminium by St. Claire Deville and other chemists, that it remained for a young graduate of Oberlin College, Charles M. Hall, to devise the process by which all the aluminium in the world is now manufactured. It occurred to young Hall, whose attention was drawn to this subject while he was still a college student, that some way might be found for extracting aluminium by electrolysis. Satisfied that it would be impossible to employ an aqueous solution, he sought for other solvents, and finally discovered that a melted bath of the double fluorides of aluminium and metals more electro-positive than aluminium, such as sodium or calcium, was a perfect solvent for alumina, taking it up as promptly as hot water takes up sugar, and dissolving as much as 25 per cent. of its weight. Having thus found an anhydrous solvent for alumina, the next step was to ascertain whether the solution would yield up the aluminium promptly to electrolysis. The most gratifying success attended his experiments, and with great intelligence and patience Hall worked out the practical application of his discovery, first establishing works at Kensington, Pennsylvania, and subsequently moving to Niagara Falls. At the present time the company has two works at Niagara; one takes 5,000 electrical horse power from the Niagara Power Company, the other takes an equal amount of current from the Canal Company.

The vessels or pots employed in the making of aluminium are rectangular iron boxes, thickly lined with carbon, and exhibiting a cavity in the carbon about 4½ feet long by 2½ feet wide, and about 6 inches deep. The carbon lining constitutes the cathode. The anodes, 40 in number, four rows of 10, consist of carbon cylinders about 3 inches in diameter and 18 inches long when new. They are supported above the pot, dipping into the bath of fused fluorides. No external heat is employed, the heat developed by the resistance to the current being all that is necessary to maintain fusion. Alumina is added from time to time as required. The process proceeds quietly, the resistance offered by the bath charged with alumina being very low, but the moment the alumina is exhausted the resistance increases four-fold. In order that the workman may be made aware of the state of the bath, an incandescent lamp is attached to each bath, which emits no light during the low resistance, but which shines brightly when the resistance, and consequently the electromotive force, at each bath increases sufficiently, so whenever one of the incandescent lamps begins to shine, the workmen hasten to stir in a fresh supply of alumina. The process proceeds quietly day and night. It is only necessary to keep the baths supplied with alumina, and every 24 hours tap the pots and draw off the metal. There are over 100 of these pots altogether, and the yield is about 100 pounds of aluminium per pot every 24 hours, or about 10,000 pounds altogether.

New uses are being constantly found for aluminium. One of the most important is its application to the casting of steel. It is regularly used now in all the steel works, being added at the rate of 4 to 6 ounces per ton to the steel just as it is poured into the ingot mould, the result being an ingot which is perfectly solid and compact throughout its mass. The metal is also beginning to find important application as a substitute for copper as a conductor for large currents of electricity.

CARBORUNDUM.

Carborundum was discovered by Mr. Edward G. Acheson, and was first manufactured at Monongahela city, in Pennsylvania. The business was subsequently transferred to Niagara Falls, where a large establishment has been erected. The process does not involve electrolysis, but the simple application of the heat generated by the passage of an enormous current through a core of coarse coke, around which is placed the material, consisting of powdered coke and sand, with a small amount of sawdust, and a still smaller quantity of common salt. From 24 to 36 hours are occupied in the process, and the final result is carborundum or carbide of silicon. Near the core the product appears in the most beautiful crystalline masses. Further away from the core the crystals become less clearly defined, and much smaller, and on the outside the product is an amorphous powder.

There are ten furnaces in operation, each of which yields about two tons of carborundum at each running. The product is broken up and sorted in sizes from grains an eighth of an inch in diameter down to the most impalpable powder. It is employed as a substitute for emery as an abrasive, is made up into wheels of all sizes, and into tools of various forms; also into hones and whetstones.

The outer layers of the mass were for a long time supposed to be useless, and accumulated in enormous piles at the works. They have since been found to be admirably adapted for the manufacture of the most refractory bricks for lining furnaces in which very high temperatures are employed. I would say more with regard to the manufacture of this beautiful and interesting substance, were it not that it has been fully described by Dr. Charles A. Kohn, late Chairman of the Liverpool Section, in the Journal of the Society for November, 1897.

Within the last few years this substance has found a new application, and it is now being used in increasingly large quantities by several of the leading manufacturers of steel castings for the prevention of blowholes. The proper quantity of the carbide is put into the empty ladle and the steel is tapped from the furnace into it; the reaction takes place at once, and the steel is then poured into the molds.

ARTIFICIAL GRAPHITE.

In the manufacture of carborundum Mr. Acheson noticed that there was always produced a layer of graphite immediately in contact with the core in the hottest part of the furnace. A study of the formation of this substance led Mr. Acheson to the conclusion that graphite was the result of a decomposition of a carbide previously formed. He found that pure carbon was not converted into graphite by electrical heat, but that when the carbon contained other materials, a small quantity of a metallic salt, or an oxide of an element, or some other element, which may be mixed with the amorphous carbon, the result is graphite. A satisfactory mixture consists of 97 parts of amorphous carbon, such as coke or charcoal, reduced to a powder, and about 3 parts of oxide of iron. Articles may be formed or molded from this material and then exposed to the action of the current.

When the electrodes of the electric furnace are 16 feet apart and the connecting cylinder of carbon containing the articles to be graphitized is 20 inches in diameter, the current starts at about 150 volts and 300 amperes, and as the graphite is formed the mass becomes a better conductor, reducing the resistance so that the voltage of the current can be reduced and the amperage increased until the graphitization is completed to the desired extent, and at the end of the operation the volts may be about 100 and the amperes 7,000.

Mr. Castner has applied this process of graphitization to the preparation of anodes for use in the electrolysis of common salt solutions, greatly increasing their durability.

I should not forget to say that the iron is volatilized during the process, and is not found in the finished graphite.

CAUSTIC SODA AND BLEACH.

Another important electro-chemical industry at Niagara Falls is the electrolysis of common salt, for the production of caustic soda and bleaching powder, by the beautiful process invented by Hamilton Y. Castner, a former pupil of our School of Mines. I presume the most of the members of the Society are so familiar with this process that it is hardly necessary for me to enlarge upon it. It will be remembered that Mr. Castner employs two separate cells in his apparatus, the salt solution being limited to one of them, where it is decomposed, the chlorine being led off to the lime chambers, while the sodium is taken up by the cathode of metallic mercury. The other chamber is employed for extracting the sodium from the amalgam, and its conversion into caustic soda; the mercury circulating freely from one chamber to the other, while none of the salt solution ever finds its way into the caustic soda compartment.

The efficiency of this process leaves nothing to be desired, and the caustic soda produced is almost chemically pure.

Near by is another establishment devoted to one of Mr. Castner's inventions. This is the extraction of metallic sodium from caustic soda by electrolysis, which is the only process, I believe, now used in the world for the production of metallic sodium in quantity, there being works in England and on the Continent carrying out the same process.

While a portion of this sodium is sent into commerce, a considerable portion of it is converted either into peroxide of sodium, for bleaching purposes, or into cyanide, for use in the cyanide process of gold extraction and by electro-platers.

Dr. L. Kahlenberg, of the University of Wisconsin, has recently made a discovery which may prove of great value in the future. He has discovered that a solution of lithium chloride in pyridine is readily decomposed by the electric current, with the deposition of pure metallic lithium. We can hardly foresee what advantages may come in the future from the substitution of such solvents as this for water in the preparation of baths for electrolysis, thus avoiding the difficulties which are encountered in working with certain metals, owing to the presence of hydrogen released from the water employed as a solvent.

Another establishment is now beginning operations at Niagara Falls for the manufacture of caustic soda and bleaching powder. It employs the process of Charles E. Acker, which differs entirely from the Castner process. The sodium chloride is in a fused condition, and a cathode of melted lead is employed, the result of which is the formation of a combination of lead and sodium, which it is proposed to use either for the manufacture of galvanic batteries as a substitute for zinc or from which the sodium can be withdrawn by distillation, or in the form of caustic soda by treatment with water.

CHLORATE.

Chlorate of potash is now manufactured on a considerable scale at Niagara Falls by the electrolysis of chloride of potassium. The process employed was invented by Messrs. Gibbs and Franchot, and appears to be an entire success. Another chlorate factory has been erected at Bay City, Michigan.

PHOSPHORUS.

Phosphorus works had been established at Niagara Falls by the Oldbury Electro-Chemical Company, the phosphorus being produced by electric heat. I have no detailed information as to the magnitude of the business.

LEAD.

The Electric Lead Reduction Company of Niagara Falls is engaged in electrolyzing galena with the production of spongy lead and sulphureted hydrogen. The process was started last spring, and the output has reached a ton of lead a day. The results so far are extremely satisfactory, and orders have been placed for new machinery which will enable the plant to turn out ten tons per day.

CALCIUM CARBIDE.

The calcium carbide industry continues to prosper in the United States. It is controlled by the Union Carbide Company, which operates two plants, the larger at Niagara Falls, and the other at Marie, Michigan. In Canada two plants are also in operation, one at St. Catherine and a new one at Ottawa. Mr. James L. Wilson, who was the pioneer in the manufacture of calcium carbide and acetylene, is interested in these Canadian plants. The output at Niagara for 1898 was from eight to ten tons a day, using 2,500 electrical horse power. In 1899 the yield was increased to from 20 to 30 tons a day, with the use of 5,000 electrical horse power. The present production of the Union Carbide Company is about 1,000 tons a month. The continuous Horrey furnaces are in operation in the two plants, and the price now of the carbide in carload lots is $70 a ton. The carbide is guaranteed to yield five cubic feet of acetylene per pound. At St. Catherine, Canada, with the use of 1,200 electrical horse power, the output is 1,200 tons of carbide per year. At both Ottawa and St. Catherine the Wilson pot furnace is employed. The export price is $60 per ton in carload lots. Much of the product is sent to Germany, Japan and South America. Owing to the fact that the carbide is classed with dangerous chemicals and explosives, the business is very much hampered by the high insurance rates and the high freights. Little progress has yet been made in the establishment of plants for lighting villages and towns with acetylene, but there seems to be a constantly increasing demand for it for isolated plants in country houses, for bicycle lamps, and many other purposes.

FERRO-CHROMIUM.

The Willson Aluminium Company is making a variety of products in the electric furnace at Holcomb Rock, Va. Ferro-chromium is in two grades, one crystalline and one solid. The furnace used is a modified Willson pot furnace. The output is 60 tons per month; the capacity will be increased to 120 tons per month after August. The product is guaranteed to contain 10 parts chromium to one part iron. An average of 11 analyses shows 70·19 per cent. chromium, 5·69 per cent. carbon, 0·62 per cent. silicon, with trifling quantities of sulphur and phosphorus. The crystalline variety is preferred by chrome steel manufacturers, because it can be more easily broken up. The principal consumers of the ferrochrome are the Carnegie Steel Company and the Bethlehem Iron Works. This ferro-chromium was used in the manufacture of the armor plates for the cruiser recently built for the Russian government.

FERRO-TITANIUM.

Ferro-titanium, containing from 15 to 83 per cent. titanium, is also manufactured by this company, as well as ferro-silicon, containing from 25 to 40 per cent. silicon, and silicon itself nearly pure (97 per cent.)

SILICON COPPER.

Silicon copper is manufactured in the Cowles electrical furnace at Lockport, New York, and is employed in purifying copper; as sent to market it contains 10 per cent. of silicon, but it is obtained with two or nearly three times that percentage.

OTHER LOCALITIES.

The electro-chemical industries at Niagara Falls, and other points in the United States, are extremely promising, and none can foresee the magnitude of future industries of this character.

Already the Ontario Power Company has been organized to establish works on the Canadian side of Niagara Falls, with a capital of $2,000,000. The works contemplated will, when finished, supply nearly 300,000 electrical horse power for use in Buffalo and various points in Canada.

Another great center of electro-chemical industry is springing up at Sault Ste. Marie, both on the American side and on the Canadian side. A company with $30,000,000 capital has been organized for the development of the water power here. Ten thousand horse power are to be taken by the American Alkali Works. Fourteen thousand horse power are already utilized on the Canadian side in making paper pulp. There are also nickel reduction works and chemical works, and other enterprises are in contemplation. Similar enterprises on a greater or smaller scale are already announced; for example, one on the Susquehanna River at Conewango, with a power house capable of producing 40,000 electrical horse power; another in North Carolina on the Catawba River to furnish 20,000 horse power; another in Michigan on the Kalamazoo River to furnish 40,000 horse power; others on the McCloud River in Shasta County, and on the South Yuba River in California; and at Chicago plans are now being made to make use of the drainage canal as a source of electrical power. In fact, we have every reason to believe that in the near future electrical plants will be established in most of the States and many of the Territories, and no one can foresee the changes that will take place in our chemical industries in consequence of the introduction of this cheap and convenient source of energy.

With regard to cost, it is too early to say at what price it will be possible to furnish electrical power. The power company at Niagara Falls has established $20 per annum per electrical horse power as its price. In other localities we are told that it can be furnished successfully at $7, and it is even said that a company is offering to furnish 375,000 horse power at $2 per annum at Shadenegan Falls on the Jacques Cartier River, 110 miles northwest of Quebec on the Great Northern Railroad.

(To be continued.)

American Factory Timekeepers Wanted in Germany.—Consul Worman, of Munich, under date of August 1, 1900, says that most factories in Germany have nothing like our electric timekeepers, and an effort to introduce them into Germany, especially into South Germany, where new enterprises are constantly being launched, ought to be successful.

GEARED LOCOMOTIVE FOR THE McCLOUD RIVER RAILROAD.

The McCloud River Railroad is located at the base of Mount Shasta, Siskiyou County, Cal. The road is at present about 20 miles long, and is an interesting piece of engineering. As there is much danger from forest fires during the long dry season, when it is operated, the use of wooden trestles or bridges was avoided. Instead of such constructions large earth fills were made at a comparatively small cost, with hydraulic nozzles. To effect this, streams of water were directed against an adjacent bank, or the cut, and the material washed into the depression and retained there by parallel dams until the solid matter settled. The waste water escaped at a suitable overflow.

During the winter months the road lies under several feet of snow. The curves in the main line are many, of 383 feet radius. On the spurs into the forest, some of the curves are 190 feet radius. The main line over the mountain is thoroughly well made. Starting from McCloud, the road has approximately 1 and 1½ miles of 2 and 3 per cent. grades; after these there are about 6 miles of steady 4 per cent. grade to the summit, which has a 2-mile level, then it is all down grade to Upton, a station on the Southern Pacific Railroad; these grades vary from nearly level to 4 per cent. All the 4 per cent. grades are compensated for curves. The distance from McCloud to Upton is approximately 18 miles, and is called the main line. The road was surveyed and constructed for the company by Mr. H. Cooley, formerly superintendent of the Mount Shasta division of the Southern Pacific Railroad.

At McCloud is located the large mill having a capacity of 150,000 feet of lumber per day. Several smaller mills are located in the neighborhood, and it is the output from these mills that is taken over the mountain pass to Upton.

Direct-connected locomotives and Heisler locomotives are used on the road. The Heisler locomotives also work on the uneven tracks that carry the timber from the interior of the forest to the mills. The cars are ordinary flat cars fitted with air brakes, and have a capacity of 20 tons each and weigh 10 tons each. They were loaded with 18,000 feet to 22,000 feet of green lumber cut from logs so heavy that many of them sink in the mill pond.

At one time the line was worked by two locomotives. One of these was a direct-connected "Mogul" locomotive which was rented from the Southern Pacific Railroad, where it was used on their heavy grades, for which it was designed; it had six drivers connected and a pony truck under the front end, the total weight being 60 tons. This engine, and a Heisler locomotive of the same total weight, together and alternately did service on the main line, hauling trains up to the summit from McCloud. The "Mogul" would haul regularly as a full load on dry rails four of the loaded cars, approximately at an average speed of 6 miles per hour up the long 4 per cent. grade. The Heisler locomotive of the same total weight, under the same conditions, regularly hauled at the same speed six of the loaded cars, with considerably less fuel per train ton. On wet rails, the Heisler locomotive had further advantages because of its great tractive power, and continued to haul the regular load of six cars of lumber, whereas the "Mogul" could haul but three loaded cars at no greater speed than the Heisler hauled the larger train. The deficiency of the latter engine was largely due to slipping of the drivers, and waste of power and adhesion caused thereby.

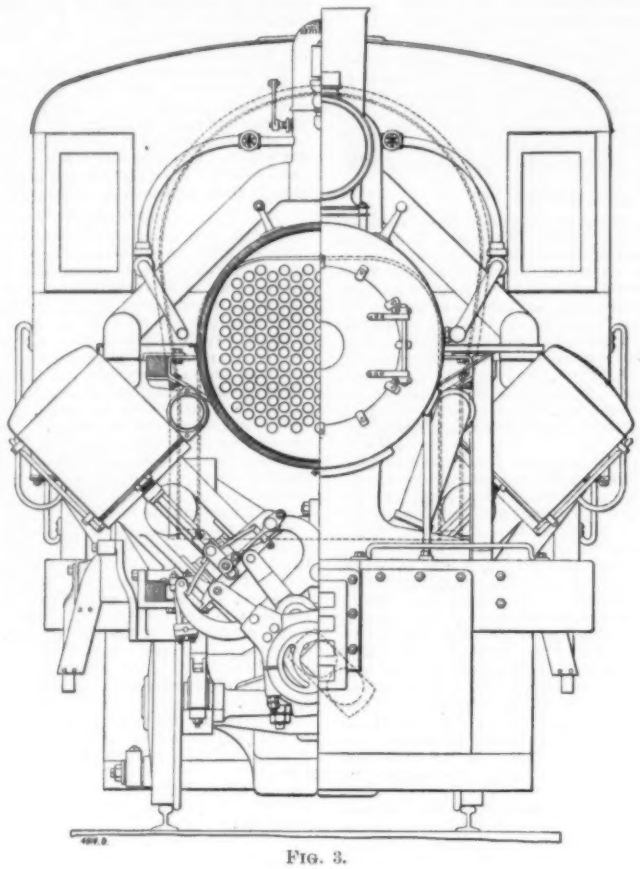


Fig. 3.

Later, a direct-connected locomotive, of the same total weight as the other engines, was also placed on the road. This engine was specially designed for the road, and was provided with a pony truck at both ends of the engine proper, to prevent climbing and crowding of the rails. Like the "Mogul," it had six connected drivers, which were made as small as possible, consistent with good design. This locomotive would not haul more cars than the "Mogul," and on wet rails its capacity was limited to three loaded cars, and often it could take but two heavy loads. The speed of the engine with the loads was no greater than that of the others. The down-grade speed of all trains was limited by the superintendent to 12 miles per hour; but at times they ran from 15 to 20 miles per hour, although this was not considered safe practice, and was for-

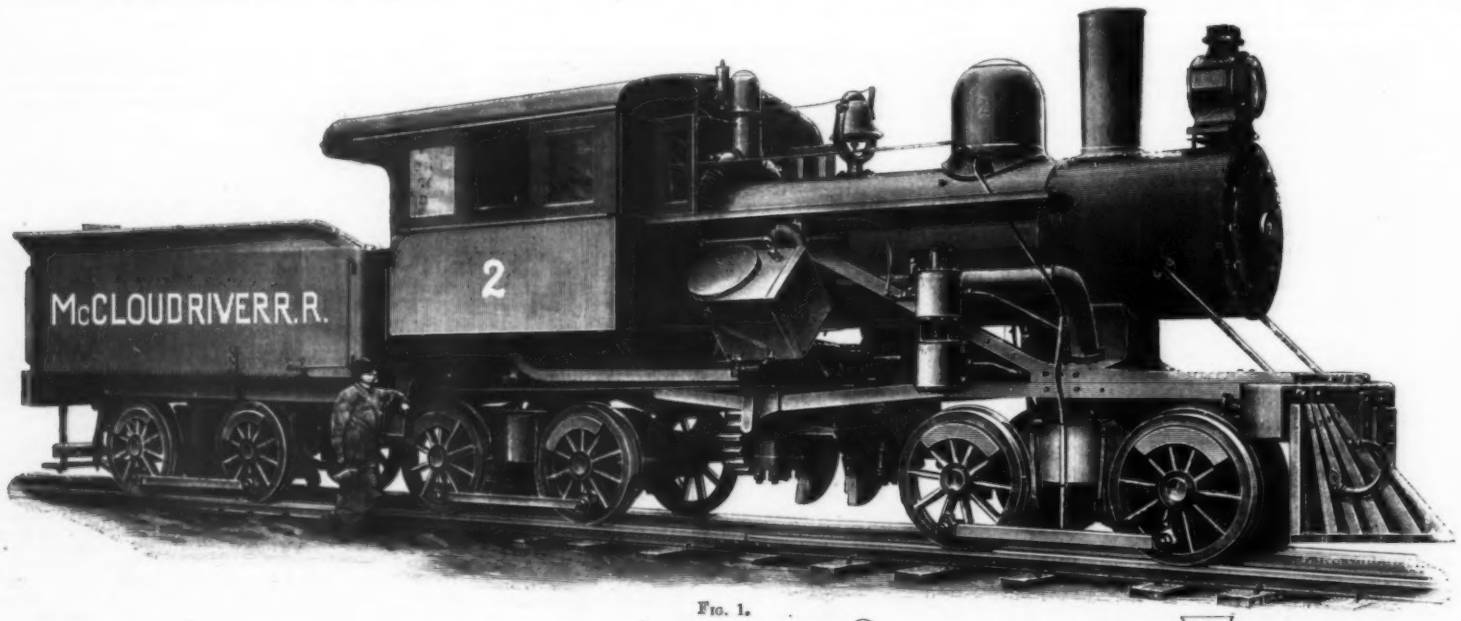
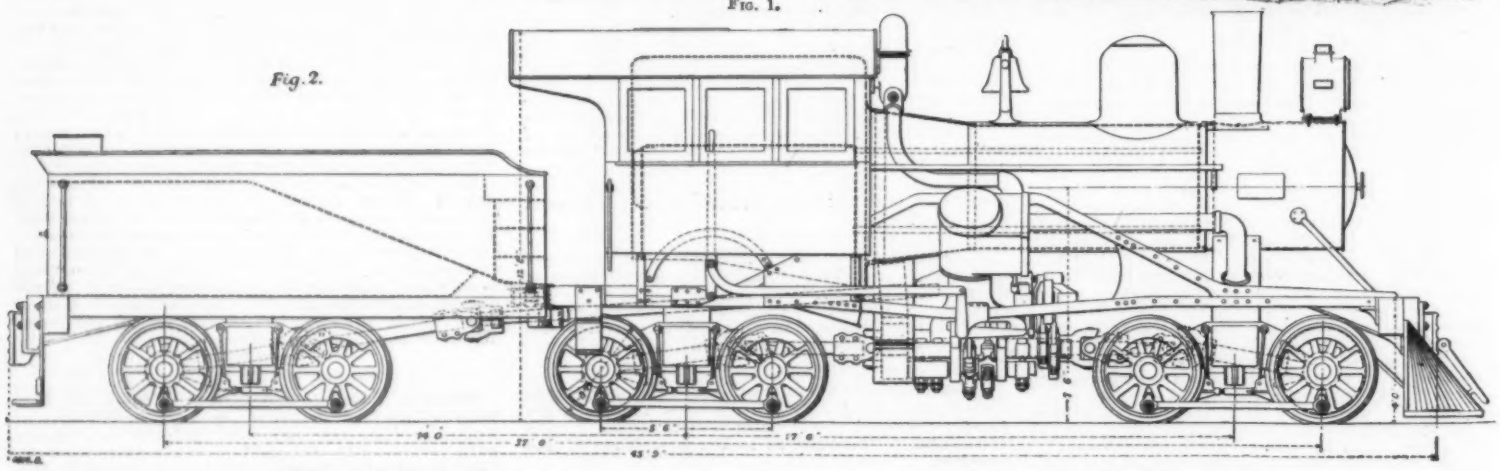


Fig. 1.

Fig. 2.



SIXTY-TON HEISLER GEARED LOCOMOTIVE FOR THE McCLOUD RIVER RAILROAD.

bidden. All the locomotives burned wood. The Heisler locomotive readily passed curves of 100 feet radius. With good fuel the Heisler locomotives will exert a tractive power equal to one-fifth of their weight at a speed of 5 or 6 miles per hour regularly as a full load.

A 60-ton Heisler locomotive, built for the McCloud River Railroad by the Stearns Manufacturing Company, of Erie, Pa., is illustrated in our engraving. Its general appearance is given by Figs. 1 and 2, which show that the engine is carried on two four-wheeled trucks, all the eight wheels being driven, while the wheels under the tender are also coupled and driven. Power is supplied by a pair of diagonal engines placed crosswise of the boiler (Fig. 3, annexed), driving on to a crankshaft lying below the boiler, and parallel to its center line. Both cylinders drive a single crank, in the manner customary with diagonal engines. There are five shafts coupled up in one length beneath the boiler of the locomotive. There is, first, the crankshaft already referred to, and at each end of it there are two other shafts, with two universal couplings (Hooke's joints) connecting them to each end of the crankshaft (Fig. 2). By these means power is conveyed to the leading axles of the front truck, and to the trailing axle of the rear truck. The end piece of shaft in each direction carries a bevel pinion (Figs. 4 and 5,

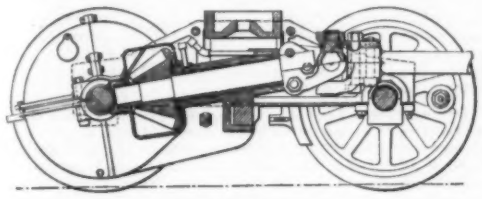


FIG. 4.

annexed) gearing with a bevel wheel on the axle. This shaft is carried in a long bearing on the bolster (Fig. 4), and has a square end (Fig. 5) on which the universal coupling is bolted. It is inclined, to enable the intermediate length of shaft to pass over the other axle of the truck. This intermediate shaft has no bearings, and allows the truck to swivel as the exigencies of track may require.

To drive the wheels of the tender, a second system of shafting is required. On the crankshaft is a toothed wheel (Fig. 1), gearing with a similar wheel on a shaft above it. These wheels are not spurs, but very long cones, as shown in dotted lines in Fig. 2; they drive an inclined shaft beneath the firebox and the footplate. This shaft ends in a universal joint, and is coupled to two other shafts in the manner already described in reference to the crankshaft. Both joints

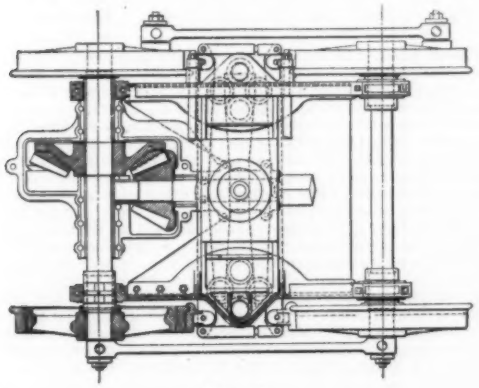


FIG. 5.

are visible under the tender, although one has to be sought for behind the leading wheel of the truck.

The following are the chief dimensions of the engine:

DIMENSIONS OF A 60-TON HEISLER LOCOMOTIVE.

Gage of track	4 feet 8½ inches.
Total weight on twelve drivers with water in boiler, tank empty	60 tons.
Weight with full supply of fuel and water	70 "
Diameter of drivers	40 inches.
Tread of tire	4⅜ "
Rigid wheel base	66 "
Total "	37 feet.
Length over all	45 feet 9 inches.
Height " "	13 " 2 "
" to center of boiler	7 " 11 "
Maximum speed	15 miles per hour.
Working speed with load	5 to 7 miles per hour.
Working speed, empty	10 to 15 miles per hour.

BOILER.

Diameter of shell	48 inches.
" of wagon top shell	64 "
Height of firebox	45½ "
Length of firebox, inside	81½ "
Width of firebox	48 "
Number of tubes	188
Length of tubes	11 feet.
Diameter of tubes	2 inches.
Working pressure	170 pounds.

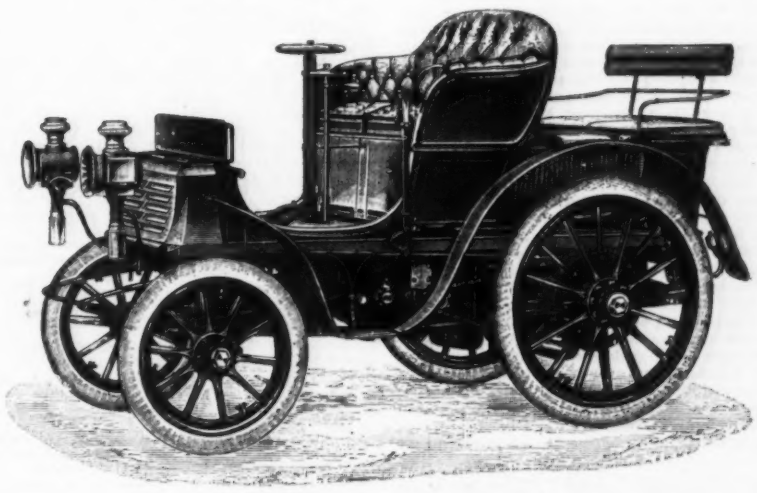
ENGINE.

Diameter of cylinders	18 inches.
Stroke of cylinders	15 "
Diameter of crankshaft	7 "
" of axle journals	6 "
Diameter of pinion shaft	5½ "
Capacity of tank	2,800 gallons.

Geared locomotives are quite common in America, where they are usually called "logging locomotives," from the fact that they are used to haul lumber, either sawn or in log, out of the woods. In some cases they run on wooden rails made of tree trunks, and have broad double-flanged wheels for the purpose. Naturally there are many of them which are roughly constructed, and quite of a different class from that which we are illustrating, and which has been put on the market to compete with heavy locomotives of the standard types. Great care has been taken to make all the parts not only of good design, but well adapted, by reason of their simplicity and accessibility, for use in remote districts where skilled assistance is scarce. The difference between financial success and failure with an engine of this kind depends greatly on the amount of the repair bill, and this matter has been kept in the forefront by the makers. For our engravings and the foregoing particulars we are indebted to Engineering.

THE BENZ SPIDER PHAETON.

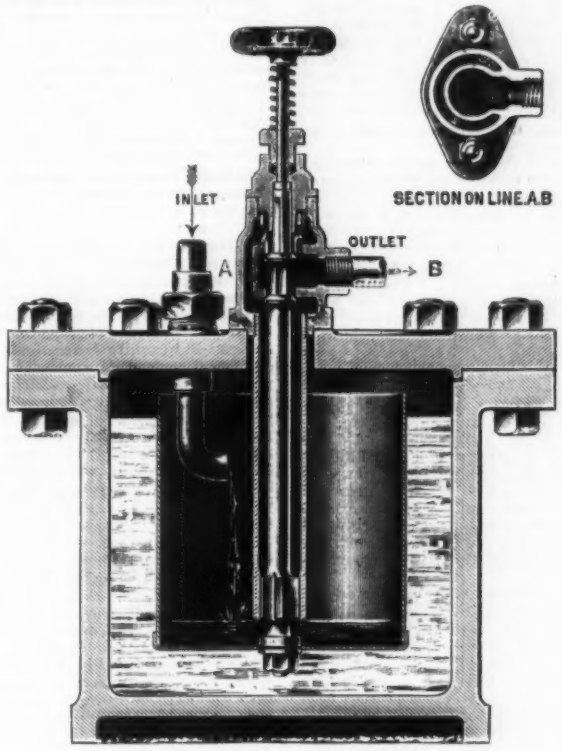
THE spider phaeton illustrated herewith is the latest production of Messrs. Benz & Company, of Mannheim. The vehicle has seating accommodation for four persons and is fitted with a horizontal engine of 9 horse power. The crank shaft works in an oil-containing case, while a central lubricator supplies the oil for the working parts. The ignition is electrical, and the cylinders are water-jacketed, the water tank being located in the forepart of the frame. Four speeds forward and reverse motion are provided, the car being, it is claimed, able to maintain an average speed of twenty-five miles per hour. Steering is controlled by a horizontal hand-wheel.—We are indebted to The Motor-Car Journal for the engraving and description.



THE BENZ SPIDER PHAETON.

THE TUNLEY STEAM TRAP.

THE accompanying illustration shows, in section, a steam trap which has been brought to our notice. The construction and working of this apparatus will be clearly seen in the illustration. For ordinary working pressures—say up to 200 pounds on the square inch—the body consists of a cast iron box. Above 200 pounds cast steel bodies are employed. Dipping down some three parts of the way into this box is a tube, and inside the tube is a valve spindle. The spindle has the valve at the top end, and its bottom end is connected to an open-topped cylinder, the spindle also being provided with winged guides at its lower end, in order to steady the cylinder. The box is nearly filled with water, so that ordinarily the cylinder is floating and the valve is kept closed. When the trap is at work, the condensed water from the steam pipes enters the floating cylinder through the elbow, as shown in the illustration, and gradually overcomes its buoyancy, with the result that the valve is opened, the water is blown up from the cylinder through the central tube, and passes away through the outlet. A section of the outlet valve on the line *A*, *B*, is given at the top of the illustration. As soon as sufficient water has been blown out to allow the buoyancy of the cylinder to again assert itself, the cylinder rises and the valve is closed, this happening before all the water has been blown from the cylinder, the weights being so arranged as to bring this about. As a result the steam cannot blow through and escape by the valve. As, however, it is occasionally necessary to blow through the trap, so as to remove any dirt or other deposit which may have found its way into the trap, a provision for effecting this has been made. At the top of the trap is a handle, which can depress the valve spindle and open the valve. This can be held down as long as is necessary, and is taken back to its original position, when pressure is removed from it, by means of a spiral spring.



THE TUNLEY STEAM TRAP.

The makers claim for this trap that it has a balanced valve which works equally well at all steam pressures; and that it is capable of dealing with a sudden rush of water, the cylinder filling, sinking, and the valve remaining open full bore until the cylinder is nearly empty again. It is further claimed that it is very simple in construction, and has no levers or joints, and also that there can be no leakage of steam for the reason already given. The valves are made renewable, and are readily got at for examination. In first setting the trap to work, the box has to be filled with water, and for this purpose a removable plug is placed in the cover.

These traps are being manufactured by Fletcher Brothers, of Ashton-under-Lyne, under license from the patentees, A. E. and J. P. Jackson.—For our engraving and the foregoing particulars we are indebted to The Engineer.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Electric Traction for Canals.—Some interesting experiments in boat traction by means of electric locomotives were recently made on behalf of the Prussian government by Messrs. Siemens & Halske, of Berlin. The scene of operations was a short length of the Finow Canal, which forms a portion of the waterway between Berlin and Stettin, and is traversed every year by about 25,000 to 26,000 boats each way. The craft used are in the main barges, some 132 feet long by 15 feet 6 inches beam, carrying 150 to 175 tons. There are also a few steam barges employed, which carry about 150 tons, and can tow a second barge. The traffic to Berlin is much heavier than toward Stettin, and in consequence three-fourths of the barges return light from the metropolis. Traction is generally effected by horses, there being a towpath on each bank, but on the down journey man traction is not infrequently relied on. In any case the speed is low, and, including stops, does not average more than about 1¼ miles per hour.

The section of canal used for the experiments was selected owing to its physical difficulties, presenting as it does several curves, in one of which, with only 328 feet radius, the waterway is spanned by a railway bridge. The line laid down for the towing engine was of 1 meter (3·28 feet) gage, the outer rail weighing 18·2 pounds per yard, while the inner, which was fixed on the inner edge of the towpath, weighed 9·1 pounds per yard. These rails, which were of the flange type, were laid partly on sleepers ballasted with gravel and partly on blocks of concrete, weighing 220 pounds each in the case of the heavier principal rail, and half this in case of the other rail. This arrangement costs more per mile than the sleepers, but has been found less expensive to maintain. Though no wharf actually existed on the length of canal experimented on, the arrangements necessary were fully tested. At one point the line was raised to a height of 9 feet 6 inches above the level of the towpath, being carried on posts and brackets. The carrying posts were 12 inches in diameter, and were spaced at 18 feet 8 inches. A cap-piece spanned the gap between posts and the principal rail was laid directly on this cap-piece, while the other was carried by a stringer, supported at each post on brackets.

The conductor for the current was supported on pine posts 23 feet long, located 35 to 44 yards apart. It consisted of 8-millimeter wire, carried by porcelain insulators. The principal rail served as conductor for the return current. The source of power was a 15 horse power portable engine, driving a 9-kilowatt dynamo; and a large storage battery was also provided. The extreme dimensions of the towing locomotive were 6 feet 10 inches in length by 4 feet 10 inches wide. Its total weight was 2 tons; but the motor was so placed that only one-fifth of this total came on the accessory rail. The motor provided was much more powerful than necessary for the work in hand, as it was capable of working at the rate of 14 to 15 horse power. Since, however, these experiments were merely preliminary ones, intended to test the possibilities of electric traction for large barges, the excess power was supplied intentionally, and the resistance requisite to call forth the full powers of the motors was in some of the experiments provided by rafts. These experiments showed the system to be capable of meeting all needs, working, as it did, with safety and economy.—Richard Guenther, Consul-General at Frankfort.

Tomatoes and Cantaloupes in Europe.—English statistics show that of late there has been a large and rapidly growing importation of tomatoes, the Canary Islands furnishing the supply, which importation amounted to 16,389 tons during the first half of this year. The wholesale price of this quantity was £331,302 (about $1,655,000). Tomatoes were but a short time ago an article of luxury in Great Britain, only used for the pampered palates of the rich; but now they have become a common dish on the tables of the working classes. In Germany, fresh tomatoes are sold at high prices (6 to 14 cents a pound, according to season). They are chiefly used to flavor meats, not stewed. Only the best hotels and the wealthy buy fresh tomatoes, which are supplied to Germany mainly by southern France. Canned tomato pulp is to be found at the grocers of large German cities, offered at a lower price, comparatively, than the fresh fruit.

Cantaloupes are a great delicacy—even more so than the pineapple—in German cities. They sell at 2 to 6 marks (50 cents to $1.50) apiece, weighing 3 to 10 pounds. Some of these are brought from Spain; others are raised in German hothouses. Considering that tomatoes have been sold as low as $5 a ton in Delaware and New Jersey, and that fine cantaloupes can be bought in Philadelphia at 1 to 3 cents apiece, the question arises, Why don't we export fresh vegetables to Europe? The growers of our Atlantic States should form an export association, which—if it will send out men of mercantile ability who can speak German and French—would find the European continent, as well as England, an excellent market for their produce. No country could compete with us in the export of agricultural and industrial products, were we to adopt the mercantile methods of European traders.—Simon W. Hanauer, Vice Consul-General at Frankfort.

Pearl Fishing in Venezuela.—Consul Plumacher sends from Maracaibo, August 8, 1900, translation of a contract for pearl fishing, dated July 17, which is summarized as follows:

The government grants to Sebastian Cipriani, for a period of twenty-five years, the exclusive rights of fishing for pearls, sponges, tortoise shell, and sea products, excepting fish, on the maritime zone comprised between Costa Firme and the island of Margarita and between the latter and the adjoining islands. Said fishing must be done by means of submarine apparatus, leaving the actual fishermen the liberty of continuing their work. Sebastian Cipriani will give the government 10 per cent. of the net profits, and will commence work six months after the signing of this contract. He will enjoy free introduction through the custom-houses of the republic of all the necessary apparatus, and no taxes will be levied on the enterprise. No similar concession will be granted any person or company during the period of this contract. This contract may be transferred to any person or company, but not to a foreign government. All controversies which may arise in the interpretation of this contract shall be decided by the courts of the republic according to Venezuelan laws.

Telegraphone Patent Rights.—Consul Worman writes from Munich, August 4, 1900, that he has received inquiries from several parties in the United States as to the patent rights for the telegraphone, the owners thereof, etc. The Bank für Handel u. Industrie, of Berlin, says Mr. Worman, represents the syndicate which controls the patents for this device. The managers have informed him that the patent rights in the United States have already been disposed of. The letter adds:

"We thank you most sincerely for your kind offer to assist us by your personal co-operation in the development of the telegraphone patents. We regret to have to inform you that we are not in a position to give you the exact information that you desire, as our attempts to produce the telegraphone in the highest possible perfection have not yet been successful."

British School of Chinese.—Consul Marshal Halstead, of Birmingham, under date of August 22, 1900, transmits a clipping from The London Daily Express, as follows:

"Thanks to the efforts of Mr. Jamieson, ex-consul-general at Shanghai, a school of practical Chinese is now being established in London under the auspices of the China Association, and at the present moment two native professors, who have been brought over from China by Mr. Jamieson for the express purpose, are receiving pupils at their domicile in Maida Vale. The instruction is specially directed to commercial subjects—correspondence, forms of accounts, bills of exchange, etc. Mr. Jamieson's exertions have been greatly impeded, of course, by the recent troubles; but it will be generally conceded that his enterprise is worthy of support by every one interested in the future of British trade in the Chinese Empire."

Demand for Telegraphic Appliances in Turkey.—Vice Consul-General Albert sends from Constantinople, September 5, 1900, a letter from Consul Norton, of Harput, in reference to the bids for supplies to be presented next month to the director of the Turkish postal and telegraphic service. The material is required in the construction of a new telegraph line.

One of the leading firms of Constantinople, says Mr. Norton, is desirous of securing quotations from a first-class American house to use in this competition. The telegraphic supplies which it has hitherto furnished the Ottoman authorities have been of English and German manufacture. The firm feels that the time is ripe for American material of the character in question to enter the Turkish market, with a fair prospect of success. Quotations should be received by October 10, though a delay of a week or two will perhaps not prevent consideration, as the date for final reception of bids is frequently postponed a fortnight or more. The house requesting these figures is reliable, and there will be no delay in payment.

The articles* required are:

Galvanized iron wire of 5 millimeters (0·177 inch), kilogrammes	† 532,830
Galvanized iron wire of 4 miliimeters (0·156 inch), kilogrammes	‡ 133,500
Large insulators, with iron accessories, pieces	40,725
Small insulators, with iron accessories, pieces	20,000
Large insulators, with iron accessories, pieces	2,225
Large insulators, with iron accessories, pieces	7,000
Posts, made after the Siemens pattern, number	1,000
Posts, made after the Siemens pattern, number	200

Offers are to be sent to M. Edouard Zanni, Haratch Han, Stamboul, Constantinople (open mail via London). Correspondence may be in English, but should be preferably in French. Prices should be expressed in francs (19·3 cents), and should be c. i. f. Constantinople, i. e., packing, freight, insurance, and all charges (except customs dues) paid to Constantinople. Payment will be made by draft on London or Paris, immediately on receipt of goods. Quotations should be received at Constantinople by October 10, or as soon thereafter as possible. In case of acceptance, a formal contract will be made at the United States consulate-general. The material will be furnished in several lots. Three months' notification will be given of the time for receiving each separate lot.

* Drawings and full descriptions (in French) of these articles are filed for reference in the Bureau of Foreign Commerce, where they can be examined by interested parties.

† 1,174,611 pounds.

‡ 294,314 pounds.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

No. 847. October 1.—*Electrical Goods in Turkey—Proposed Changes in the German Tariff—Commercial Union of Belgium—Steamship Service with Para; Financial Crisis—*Peat as Fuel in Russia—*Swiss Steel Industry.

No. 848. October 2.—*American Fruit in Germany—Commerce and Industry of Japan—Need of Communication with Singapore—Demand for Trunks and Stationery in Madagascar.

No. 849. October 3.—*Industrial Conditions in South Africa—Railway Strike at Cardiff—Foreign Mining Capital in Russia—Tariff Reductions in the Canary Islands—German Rules as to Showing of Flags by Vessels—Japanese Immigrants.

No. 850. October 4.—Coal in Italy—United States Coal in Marseilles—United States Coal in Nantes—American Coal in Great Britain—American Coal in London—American Coal in the Netherlands—High Coal Prices in Austria—American Coal in Algiers—Coal in the Canary Islands—Gibraltar Coal Trade—Demand for United States Coal in Russia—American Coal in Sierra Leone—Coal Trade of Formosa—Coal in the Yukon—Prussian Freight Rates on Coal.

No. 851. October 5.—Trade and Economic Conditions in Peru—Effects of the Canadian Preferential Tariff—American and Russian Petroleum in the World's Markets—Petroleum in Roumania—*Consumption of Locomotive Smoke—*German Rubber Association.

No. 852. October 6.—*Manufacture of Patent Fuels in Wales—Increase in Nicaraguan Postage Rate—*Irrigation in Spain—*Electricity on German Farms—*Brushes in Germany—*Commercial University for Cologne.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

TRADE NOTES AND RECEIPTS.

Red Stuff for Polishing Metals.—To a solution of green vitriol add, dissolved, some sorrel salt. The resulting precipitate of pale yellow ferric oxalate is filtered off and dried. Next subject the ferric oxalate to a moderate stove heat in an iron dish, whereby the oxalic acid is expelled with decomposition, and very pure iron oxide of the greatest fineness remains behind.—Deutsche Schlosser Zeitung.

Impregnation of Wood.—According to Dr. Winkelmann a good process for fire-proofing wood is as follows: Subject the wood or wooden objects for 6 to 8 hours to the boiling heat of a solution of 33 grammes of manganese chloride, 20 grammes of orthophosphoric acid, 12 grammes of magnesium carbonate, 10 grammes of boracic acid and 25 grammes of ammonium chloride in 1 liter of water. The wood thus treated is said to be perfectly incombustible even at great heat, and besides to be also protected by this method against decay, injury by insects and putrefaction.—Zeitschrift für Gewerbehygiene.

Gloss Starch.—In order to impart a fine luster to ironed wash, especially shirt fronts, collars and cuffs, the following composition is very valuable. Boil in 1 liter of water 60 grammes of white glycerin, 25 grammes of borax, 45 grammes of spermaceti and 25 grammes of gum arabic until all has dissolved; fill it, after cooling, into clean bottles and keep well corked. To one liter of ordinary boiled starch add, in starching, 10 tablespoonfuls of this mixture. If, furthermore, a gloss flat-iron is used in ironing and it is handled properly, the linen will become very stiff and lustrous.—Färber und Wäscher.

Incongealable Liquid.—In numerous instances a fluid is required which does not freeze. For many machines and in artillery, glycerin, which is quite expensive, is employed for this purpose. An admixture of alcohol increases the cost still more. The Revue Technique recommends in place thereof a 28 per cent. solution of calcium chloride, which is very cheap and remains liquid up to a temperature of 32° C. It does not attack any metals, which is of especial importance. In lieu thereof one may also employ the somewhat dearer solution of calcium chloride 10 parts, aluminium chloride 20 parts, and magnesium chloride 1 part.

Process to Impregnate Fabrics.—The fabric is first saturated with a celluloid solution of little concentration or density, e. g., of the consistency of olive oil, which solution penetrates deeply into the tissue; dry quickly in a heating chamber and saturate with a celluloid solution of greater concentration, e. g., of the flowing capacity of concentrated molasses. In the case of admixture of oil to the celluloid solution, same amounts to but little in the first solution, e. g., 1 to 2 per cent., in the following ones to more, e. g., 5 to 8 per cent., while the outer layer contains very little or no oil. A fabric impregnated in this manner possesses a very flexible surface, because the outer layer may be very thin, while the interior consists of many flexible fibers surrounded by celluloid.—Brünner Monatschrift für Textil Industrie.

New Kind of Glass.—A new variety of glass in which a metallic trellis is embedded is manufactured especially in England and Belgium. The operation is executed at the moment when the glass is still glowing and prevents the contact with the air, consequently also the oxidation of the grille-work. Articles produced by this process can be cut and smoothed and possess great resistance to knocks, pressure, and quick changes of temperature. The new glass affords almost absolute protection against breakage, so that it may be used in place of ordinary glass, as well as in all cases where the latter was not suitable, owing to its fragility. For various building purposes, e. g. for roofing a restaurant, etc., with skylight, the new material is very useful, rendering the employment of an outer protective trellis unnecessary. Besides, this roofing may be readily cleaned without any danger of the workmen breaking through, even in case of but slight thickness of the glass.—Uhland's Technische Rundschau.

Drying Lacquered Articles by Means of Ozone.—In order to make use of the drying qualities of ozone, Carl Hoch has constructed a contrivance which is arranged as follows: In a comparatively small clay apparatus, air is heated and purified by a special method; it is prepared for the formation of ozone and then mixed with plenty of ozone by the application of chemical substances. The air thus prepared is conveyed by a pipe into the lacquering oven and passes through it, so that the surfaces of the lacquered goods are permanently in contact with fresh ozone. In this manner lacquers which otherwise require a temperature of 300° C. to dry are said to be dried promptly at 30° to 35° and show excellent hardness and elasticity. Hence, this process is suited for lacquering metallic goods, particularly sheet-metal ware soldered with tin, as well as any other material, as patent leather or articles consisting partly of metal and partly of readily combustible bodies, such as wood and leather.—Farben Zeitung.

Action of Oils and Greases on Metals.—Mineral lubricating oil has no effect on tin and copper; it attacks brass least and lead most.

Olive oil attacks copper most, zinc the least.

Rape-seed oil does not injure brass and tin, and attacks copper the most and iron the least.

Tallow oil has the strongest action on copper, the weakest on tin.

Lard oil attacks copper most and zinc least.

Cotton-seed oil acts strongest on zinc, and least on lead.

Sperm oil's strongest effect is upon zinc, its weakest on brass.

Whale oil does not attack tin at all, while it acts most on brass and least on lead.

Seal oil acts most on copper and least on brass.

On the other hand, experiments have demonstrated that iron is attacked most by tallow oil, least by seal oil and not at all by rape-seed oil. Tin is not acted upon by rape-seed oil, it is least attacked by olive oil and most by whale oil. Almost the same action have lard oil and sperm oil. Zinc does not seem to be attacked by mineral lubricating oil. The least action seems to be exercised by lard oil, the strongest by sperm oil. Copper is least attacked by sperm oil and most by tallow oil.—Anzeiger für die Draht Industrie

THE AGE OF THE EARTH.*

By Prof. W. J. SOLLAS, D.Sc.

THE close of one century, the dawn of another, may naturally suggest some brief retrospective glance over the path along which our science has advanced, and some general survey of its present position; but other connection with geology the beginnings and endings of centuries have none. The great periods of movement have hitherto begun, as it were, in the early twilight hours, long before the dawn. Thus the first step forward, since which there has been no retreat, was taken by Steno in the year 1669; more than a century elapsed before James Hutton (1785) gave fresh energy and better direction to the faltering steps of the young science; while it was less than a century later (1863) when Lord Kelvin brought to its aid the powers of the higher mathematics and instructed it in the teachings of modern physics. From Steno onward the spirit of geology was catastrophic; from Hutton onward it grew increasingly uniformitarian; from the time of Darwin and Kelvin it has become evolutional. The ambiguity of the word "uniformitarian" has led to a good deal of fruitless logomachy, against which it may be as well at once to guard by indicating the sense in which it is used here. In one way we are all uniformitarians, i. e., we accept the doctrine of the "uniform action of natural causes," but, as applied to geology, uniformity means more than this. Defined in the briefest fashion it is the geology of Lyell. Hutton had given us a "Theory of the Earth," in its main outlines still faithful and true; and this Lyell spent his life in illustrating and advocating; but as so commonly happens, the zeal of the disciple outran the wisdom of the master, and mere opinions were insisted on as necessary dogma. What did it matter if Hutton as a result of his inquiries into terrestrial history had declared that he found no vestige of a beginning, no prospect of an end? It would have been marvelous if he had! Consider that when Hutton's "Theory" was published, William Smith's famous discovery had not been made, and that nothing was then known of the orderly succession of forms of life, which it is one of the triumphs of geology to have revealed; consider, too, the existing state of physics at the time, and that the modern theories of energy had still to be formulated; consider, also, that spectroscopy had not yet lent its aid to astronomy and the consequent ignorance of the nature of nebulæ; and then, if you will, cast a stone at Hutton. With Lyell, however, the case was different. In pressing his uniformitarian creed upon geology, he omitted to take into account the great advances made by its sister sciences, although he had knowledge of them, and thus sinned against the light. In the last edition of the famous "Principles" we read: "It is a favorite dogma of some physicists that not only the earth, but the sun itself, is continually losing a portion of its heat, and that as there is no known source by which it can be restored, we can foresee the time when all life will cease to exist on this planet, and on the other hand we can look back to a period when the heat was so intense as to be incompatible with the existence of any organic beings such as are known to us in the living or fossil world. . . . A geologist in search of some renovating power by which the amount of heat may be made to continue unimpaired for millions of years, past and future, in the solid parts of the earth . . . has been compared by an eminent physicist to one who dreams he can discover a source of perpetual motion and invent a clock with a self-winding apparatus. But why should we despair of detecting proofs of such regenerating and self-sustaining power in the works of a Divine Artificer?" Here we catch the true spirit of uniformity; it admittedly regards the universe as a self-winding clock, and barely conceals a conviction that the clock was warranted to keep true Greenwich time. The law of the dissipation of energy is not a dogma, but a doctrine drawn from observation, while the uniformity of Lyell is in no sense an induction; it is a dogma in the narrowest sense of the word, unproved, incapable of proof; hence perhaps its power upon the human mind; hence, also, the transitoriness of that power. Again, it is only by restricting its inquiries to the stratified rocks of our planet that the dogma of uniformity can be maintained with any pretense of argument. Directly we begin to search the heavens, the possibility, nay even the likelihood, of the nebular origin of our system, with all that it involves, is borne in upon us. Lyell therefore consistently refused to extend his gaze beyond the rocks beneath his feet, and was thus led to do a serious injury to our science. He severed it from cosmogony, for which he entertained and expressed the most profound contempt, and from the mutilation thus inflicted geology is only at length making a slow and painful recovery. Why do I dwell on these facts? To depreciate Lyell? By no means. No one is more conscious than I of the noble service which Lyell rendered to our cause; his reputation is of too robust a kind to suffer from my unskillful handling, and the fame of his solid contributions to science will endure long after these controversies are forgotten. The echoes of the combat are already dying away, and uniformitarians, in the sense already defined, are now no more. Indeed, were I to attempt to exhibit any distinguished living geologist as a still surviving supporter of the narrow Lyellian creed, he would probably feel, if such a one there be, that I was unfairly singling him out for unmerited obloquy.

Our science has become evolutional, and in the transformation has grown more comprehensive; her petty parochial days are done, she is drawing her provinces closer around her, and is fusing them together into a united and single commonwealth—the science of the earth.

Not merely the earth's crust, but the whole of earth-knowledge is the subject of our research. To know all that can be known about our planet, this, and nothing less than this, is its aim and scope. From the morphological side geology inquires, not only into the existing form and structure of the earth, but also into the series of successive morphological states through which it has passed in a long and changeful development. Our science inquires also into the distribution of the earth in time and space; on the physiological side it studies the movements and activities of our planet; and not content with all this, it extends its researches into ætiology and endeavors to arrive at a science of causation. In these pursuits, geology calls all the other sciences to her aid. In our commonwealth there are no outlanders: if an eminent physicist enter our territory, we do not begin at once to prepare for war, because the very fact of his undertaking a geological inquiry of itself confers upon him all the duties and privileges of citizenship. A physicist studying geology is by definition a geologist. Our only regret is, not that physicists occasionally invade our borders, but that they do not visit us oftener and make closer acquaintance with us.

EARLY HISTORY OF THE EARTH—FIRST CRITICAL PERIOD.

If I am bold enough to assert that cosmogony is no longer alien to geology, I may proceed further, and taking advantage of my temerity pass on to speak of things once not permitted to us. I propose, therefore, to offer some short account of the early stages in the history of the earth. Into its nebular origin we need not inquire—that is a subject for astronomers. We are content to accept the infant earth from their hands as a molten globe ready made, its birth from a gaseous nebula duly certified. If we ask, as a matter of curiosity, what was the origin of the nebula, I fear even astronomers cannot tell us. There is an hypothesis which refers it to the clashing of meteorites, but in the form in which this is usually presented it does not help us much. Such meteorites as have been observed to penetrate our atmosphere and to fall on to the surface of the earth prove on examination to have had an eventful history of their own, of which not the least important chapter was a passage through a molten state; they would thus appear to be the products rather than the progenitors of a nebula.

We commence our history, then, with a rapidly rotating molten planet, not impossibly already solidified about the center and surrounded by an atmosphere of great depth, the larger part of which was contributed by the water of our present oceans, then existing in a state of gas. This atmosphere, which exerted a pressure of something like 5000 pounds to the square inch, must have played a very important part in the evolution of our planet. The molten exterior absorbed it to an extent which depended on the pressure, and which may some day be learnt from experiment. Under the influence of the rapid rotation of the earth, the atmosphere would be much deeper in equatorial than polar regions, so that in the latter the loss of heat by radiation would be in excess. This might of itself lead to convectional currents in the molten ocean. The effect on the atmosphere is very difficult to trace, but it is obvious that if a high-pressure area originated over some cooler region of the ocean, the winds blowing out of it would drive before them the cooler superficial layers of molten material; and as these were replaced by hotter lava streaming from below, the tendency would be to convert the high into a low-pressure area, and to reverse the direction of the winds. Conversely under a low-pressure area the in-blowing winds would drive in the cooler superficial layers of molten matter that had been swept away from the anticyclones. If the difference in pressure under the cyclonic and anticyclonic areas were considerable, some of the gas absorbed under the anticyclones might escape beneath the cyclones, and in a later stage of cooling might give rise to vast floating islands of scoria. Such islands might be the first foreshadowings of the future continents. Whatever the ultimate effect of the reaction of the winds on the currents of the molten ocean, it is probable that some kind of circulation was set up in the latter. The universal molten ocean was by no means homogeneous; it was constantly undergoing changes in composition as it reacted chemically with the internal metallic nucleus; its currents would streak the different portions out in directions which in the northern hemisphere would run from northeast to southwest, and thus the differences which distinguish particular petrological regions of our planet may have commenced their existence at a very early stage. It is possible that as our knowledge extends we shall be able by a study of the distribution of igneous rocks and minerals to draw some conclusions as to the direction of these hypothetical lava currents? Our planet was profoundly disturbed by tides, produced by the sun; for as yet there was no moon; and it has been suggested that one of its tidal waves rose to a height so great as to sever its connection with the earth and to fly off as the infant moon. This event may be regarded as marking the first critical period, or catastrophe if we please, in the history of our planet. The career of our satellite, after its escape from the earth, is not known till it attained a distance of nine terrestrial radii; after this its progress can be clearly followed. At the eventful time of parturition the earth was rotating, with a period of from two to four hours, about an axis inclined at some 11° or 12° to the ecliptic. The time which has elapsed since the moon occupied a position nine terrestrial radii distant from the earth is at least fifty-six to fifty-seven millions of years, but may have been much more. Prof. Darwin's story of the moon is certainly one of the most beautiful contributions ever made by astronomy to geology, and we shall all concur with him when he says, "A theory reposing on veræ causæ, which brings into quantitative correlation the length of the present day and month, the obliquity of the ecliptic, and the inclination and eccentricity of the lunar orbit, must, I think, have strong claims to acceptance."

The majority of geologists have long hankered after a metallic nucleus for the earth, composed chiefly, by analogy with meteorites, of iron. Lord Kelvin has admitted the probable existence of some such nucleus, and lately Prof. Wiechert has furnished us with arguments—"powerful" arguments Prof. Darwin terms them—in support of its existence. The interior of the earth for four-fifths of the radius is composed, according to Prof. Wiechert, chiefly of metallic iron, with a density of 8·2; the outer envelope, one-fifth of the radius, or about 400 miles in thickness, consists of silicates, such as we are familiar with in igneous rocks and meteorites, and possesses a density of 3·2. It was from this outer envelope when molten that the moon was trundled off, twenty-seven miles in depth going to its formation. The density of this material, as we have just seen, is supposed to be 3·2; the density of the moon is 3·39, a close approximation, such difference as exists being completely explicable by the comparatively low temperature of the moon.

The outer envelope of the earth which was drawn off to form the moon was, as we have seen, charged with steam and other gases under a pressure of 5,000 pounds to the square inch; but as the satellite wandered away from the parent planet, this pressure continuously diminished. Under these circumstances the moon would become as explosive as a charged bomb, steam would burst forth from numberless volcanoes, and while the face of the moon might thus have acquired its existing features, the ejected material might possibly have been shot so far away from its origin as to have acquired an independent orbit. If so, we may ask whether it may not be possible that the meteorites, which sometimes descend upon our planet, are but portions of its own envelope returning to it. The facts that the average specific gravity of those meteorites which have been seen to fall is not much above 3·2, and that they have passed through a stage of fusion, are consistent with this suggestion.

SECOND CRITICAL PERIOD—"CONSISTENTIOR STATUS."

The solidification of the earth probably became completed soon after the birth of the moon. The temperature of its surface at the time of consolidation was about 1,170° C., and it was therefore still surrounded by its primitive deep atmosphere of steam and other gases. This was the second critical period in the history of the earth, the stage of the "consistentior status," the date of which Lord Kelvin would rather know than that of the Norman Conquest, though he thinks it lies between twenty and forty millions of years ago, probably nearer twenty than forty.

Now that the crust was solid there was less reason why movements of the atmosphere should be unsteady, and definite regions of high and low pressure might have been established. Under the high-pressure areas the surface of the crust would be depressed; correspondingly under the low-pressure areas it would be raised; and thus from the first the surface of the solid earth might be dimpled and embossed.*

THIRD CRITICAL PERIOD—ORIGIN OF THE OCEANS.

The cooling of the earth would continuously progress, till the temperature of the surface fell to 370° C., when that part of the atmosphere which consisted of steam would begin to liquefy; then the dimples on the surface would soon become filled with superheated water, and the pools so formed would expand and deepen, till they formed the oceans. This is the third critical stage in the history of the earth, dating, according to Prof. Joly, from between eighty and ninety millions of years ago. With the growth of the oceans the distinction between land and sea arose—in what precise manner we may proceed to inquire. If we revert to the period of the "consistentior status," when the earth had just solidified, we shall find, according to Lord Kelvin, that the temperature continuously increased from the surface, where it was 1,170° C., down to a depth of twenty-five miles, where it was about 1,430° C., or 260° C. above the fusion point of the matter forming the crust. That the crust at this depth was not molten but solid is to be explained by the very great pressure to which it was subjected—just so much pressure, indeed, as was required to counteract the influence of the additional 260° C. Thus if we could have reduced the pressure on the crust we should have caused it to liquefy; by restoring the pressure it would resolidify. By the time the earth's surface had cooled down to 370° C. the depth beneath the surface at which the pressure just kept the crust solid would have sunk some slight distance inward, but not sufficiently to affect our argument.

The average pressure of the primitive atmosphere upon the crust can readily be calculated by supposing the water of the existing oceans to be uniformly distributed over the earth's surface, and then by a simple piece of arithmetic determining its depth; this is found to be 1·718 miles, the average depth of the oceans being taken at 2·393 miles. Thus the average pressure over the earth's surface, immediately before the formation of the oceans, was equivalent to that of a column of water 1·718 miles high on each square inch. Supposing that at its origin the ocean were all "gathered together into one place," and "the dry land appeared," then the pressure over the ocean floor would be increased from 1·718 miles to 2·393 miles, while that over those portions of the crust that now formed the land would be diminished by 1·718 miles. This difference in pressure would tend to exaggerate those faint depressions which had arisen under the primitive anti-cyclonic areas, and if the just soldified material of the earth's crust were set into a state of flow, it might move from under the ocean into the bulgings which were rising to form the land, until static equilibrium were established. Under these circumstances the pressure of the ocean would be just able to maintain a column of rock 0·886 mile in height, or ten twenty-sevenths of its own depth. It could do no more; but in order that the dry land may appear, some cause must be found competent either to lower the ocean bed the remaining seventeen twenty-sevenths of its full depth, or to raise the continental bulgings to the same extent. Such a cause may, I think, be discovered in a further effect of the reduction in pressure over the continental areas. Previous to the condensation of the ocean, these, as we have seen, were subjected to an atmospheric pressure equal to that of a column of water 1·718 miles in height. This pressure was contributory to that which caused the outer twenty-five miles of the earth's crust to become solid; it furnished, indeed, just about one-fortieth of that pressure, or enough to raise the fusion point 6° C. What, then, might be expected to happen when the continental area was relieved of this load? Plainly a liquefaction and corresponding expansion of the underlying rock.

But we will not go so far as to assert that actual liquefaction would result; all we require for our explanation is a great expansion; and this would probably follow, whether the crust were liquefied or not. For there is good reason to suppose that when matter at a temperature above its ordinary fusion point is compelled into the solid state by pressure, its volume

* Opening address by the President of the Section of Geology, British Association.

* It would be difficult to discuss with sufficient brevity the probable distribution of these inequalities, but it may be pointed out that the moon is possibly responsible, and that in more ways than one, for much of the existing geographical asymmetry.

is very responsive to changes either of pressure or temperature. The remarkable expansion of liquid carbon dioxide is a case in point: 120 volumes of this fluid at —20° C. become 150 volumes at 33° C.; a temperature just below the critical point. A great change of volume also occurs when the material of igneous rocks passes from the crystalline state to that of glass; in the case of diabase* the difference in volume of the rock in the two states at ordinary temperatures is 13 per cent. If the relief of pressure over the site of continents were accompanied by volume changes at all approaching this, the additional elevation of seventeen twenty-sevenths required to raise the land to the sea level would be accounted for.† How far down beneath the surface the unloading of the continents would be felt it is difficult to say, though the problem is probably not beyond the reach of mathematical analysis; if it affected an outer envelope twenty-five miles in thickness, a linear expansion of 4 per cent. would suffice to explain the origin of ocean basins. If now we refer to the dilatation determined by Carl Barus for rise in temperature in the case of diabase, we find that between 1,093° and 1,112° C. the increase in volume is 3·3 per cent. As a further factor in deepening the ocean basins may be included the compressive effect of the increase in load over the ocean floor; this increase is equal to the pressure of a column of water 0·675 mile in height, and its effect in raising the fusion point would be 2° C., from which we may gain some kind of idea of the amount of compression it might produce on the yielding interior of the crust. To admit that these views are speculative will be to confess nothing; but they certainly account for a good deal. They not only give us ocean basins, but basins of the kind we want, that is, to use a crude comparison once made by the late Dr. Carpenter, basins of a tea-tray form, having a somewhat flat floor and steeply sloping sides; they also help to explain how it is that the value of gravity is greater over the ocean than over the land.

The ocean when first formed would consist of highly heated water, and this, as is well known, is an energetic chemical reagent when brought into contact with silicates like those which formed the primitive crust. As a result of its action, saline solutions and chemical deposits would be formed; the latter, however, would probably be of no great thickness, for the time occupied by the ocean in cooling to a temperature not far removed from the present would probably be included within a few hundreds of years.

(To be continued.)

AUSTRALIA: THE WONDERFUL ISLAND CONTINENT.

By SIDNEY DICKINSON, F.R.G.S.

How shall I describe Australia—that country of the strange, the weird, the unaccustomed? It is a country in which nature has established conditions unknown elsewhere, and where civilization, encountering novel surroundings, is developing in new and interesting ways. It is the Land of the Great Secret, into which some four million human beings are prying; the Land of a Colossal Experiment, under conditions of location and environment which make the experience of other countries of little practical use to it.

It is full of anomalies in its human, animal, and vegetable life. Its native inhabitants show a degree of intelligence below even the people of the Stone Age. Its animals perpetuate types that disappeared from nearly every other part of the globe some millions of years ago. Its trees and plants represent species found elsewhere only in the chalk and coal measures—altogether it is a country which nature seems to have lost sight of, or, perhaps, to have particularly favored by preserving it from the cataclysms that have filled other lands with the debris of annihilated centuries.

Australia, the Island Continent, although appearing comparatively insignificant upon the map of the world, is, nevertheless, very nearly the size of the United States, our possessions in Alaska being left out of the account. The interior is a desert more inhospitable than Sahara. Along the shore are a few widely-separated and attractive cities, and in the middle belt of a few hundred miles that separates the outer desolation of ocean and the inner desolation of sand is an interesting country of varying fertility, wherefrom widely-scattered communities and isolated farmers and ranch owners bring forth the various products that have made Australia, in proportion to her population, one of the richest countries in the world.

When, a century and a quarter ago, Captain Cook dropped anchor in that placid expanse of water which, from the interesting plants and trees he found along its shores, he called "Botany Bay," he little dreamed that there lay within a few cannot shots of his ships the site of a city destined to be the metropolis of a group of states that should present the highest development of England's colonial system. Still less did his prescient eye observe the statue to his fame which, standing in beautiful Hyde Park, in the heart of the city of Sydney, commemorates the fame of this Columbus of the South, perpetuates his deeds, and records his death at the hands of the savages of far-off Hawaii. Cook himself never saw the ground that now supports his monument. The beetling cliffs which guard the entrance of Sydney Harbor concealed from him one of the grandest roadsteads in the world as he passed, far out to sea, and a discovery that would have been one of the greatest he had made was thus withheld from him.

Sydney, the most progressive as it is one of the most delightful cities of the Southern Hemisphere, competes with Melbourne for the honor of being the metropolis of Australia. With very little difference between them in the matter of population, these two cities are widely separated in appearance and individual quality. Sydney (surrounding the upper end and sides of her justly famous bay with the main city itself and its dozen picturesque suburbs) strongly suggests in flavor such English coast towns as Southampton; Melbourne, less attractive in location, is more typically Australian, and, to American visitors at least, is a more familiar place from its resemblance, in many features, to certain cities in the Western United States. Sydney has more culture, and a superior air of leisure and refinement, which of right belong to a community that is older and of more definitely-established social institutions; Melbourne has more enterprise, more of the American quality of "hustle," a more energetic and less conservative population. Sydney's public gardens, libraries, and art gallery—the last being one of the finest municipal establishments of the kind in the world and enjoying a government subvention of £5,000 a year—are the finest in Australia; Melbourne's parliament house, its cathedral and churches, its law courts, its series of magnificent town halls that grace every important suburb, far surpass similar monuments in Sydney; both have notable universities, yet the chief thing that differentiates these cities, one from the other, appears to lie in the general fact that Sydney is the leader in intellectual, Melbourne in material advancement. The more assured and stable wealth of Sydney is shown in such palatial structures as the Australian Club, the leading hotel, the vast city hall with its auditorium seating some six thousand persons and its magnificent organ, one of the largest in the world; Melbourne has a less-finished air, but in enterprise and development of the material resources of Australia it holds an undoubted leadership.

A singular fact in relation to Australia is that, in effect, the country has no inland cities. Sydney, Melbourne, Adelaide, Brisbane, the capitals, respectively, of the four leading colonies, are either directly upon the shore or closely connected with it by navigable rivers or short railway lines. Throughout the interior there is but one town that can fairly claim municipal importance—Ballarat, with some fifty thousand inhabitants; and that is less than a hundred miles from the seaboard. This lack of concentration of the inland population is explained by the lack of water-ways, and

A SELECTOR'S HOME.

A TYPICAL NATIVE.

LOADING WOOL AT A RAILWAY STATION.

* C. Barus so names the material on which he experimented; apparently the rock is a fresh dolerite without olivine.

† Prof. Fitzgerald has been kind enough to express part of the preceding explanation in a more precise manner for me. He writes: "It would require a very nice adjustment of temperatures and pressures to work out in the simple way you state it; but what is really involved is that in a certain state diabase (and everything that changes state with a considerable change of volume) has an enormous isothermal compressibility. Although this is very enormous in the case of bodies which melt suddenly, like ice, it would also involve very great compressibilities in the case of bodies even which melted gradually, if they did so at all quickly, i. e., within a small range of temperature. What you postulate, then, is that at a certain depth diabase is soft enough to be squeezed from under the oceans, and that, being near its melting point, the small relief of pressure is accompanied by an enormous increase in volume which helped to raise the continents. Now that I have written the thing out in my own way, it seems very likely. It is, anyway, a suggestion quite worthy of serious consideration, and a process that in some places must almost certainly have been in operation, and maybe is still operative. Looking at it again, I hardly think it is quite likely that there is or could be much squeezing sideways of liquid or other viscous material from under one place to another, because the elastic yielding of the inside of the earth would be much quicker than any flow of this kind. This would only modify your theory, because the diabase that expands so much on the relief of pressure might be that already under the land, and raising up this latter, partly by being pushed up itself by the elastic relief of the inside of the earth and partly by its own enormous expansibility near its melting point. The action would be quite slow, because it would cool itself so much by its expansion that it would have to be warmed up from below, or by tidal earth-squeezing, or by chemical action, before it could expand isothermally."

by the general unproductiveness of the soil; for there is nothing to support large cities unless, like Ballarat, they are the centers of extensive mining districts, and points of export, also, for the wool-growing interest, which combines with the gold output to form the main sources of colonial wealth.

It is in the interior that the visitor finds the characteristic life, both human and animal, of Australia. Cities everywhere—barring the national peculiarities of their inhabitants—are much alike; but in no part of the world is the transition from urban to rural life so striking as in the Antipodes. It is not upon its scenery that Australia can found her claims to interest; no country of the globe is so lacking, on the whole, in the elements of the picturesque, yet, on the other hand, hardly any other country is so profoundly interesting; and this because of the strangeness of vegetation and life, the vast sweep of its monotonous plains and the

"OVERLANDING" CATTLE

effect of space, to which only the prairies of America can offer a parallel. The monotony of form in the Australian landscape is matched by its monotony of vegetation; hardly any other tree than the eucalyptus, with its dusty green foliage, is to be seen, and although it boasts some five hundred varieties, there is little to differentiate them for the ordinary observer. One of the strange contradictions of nature for which Australia is famous is seen in the eucalyptus, or "gum," as it is more generally known. It does not shed its leaves, but its bark, and although densely foliaged, casts no shade—its leaves being set with their edges, instead of their sides, against the sun, so that the light falls through them as through a cobweb. In clearing land these trees are "ring-barked," being thus left to die and fall by their own decay, or felled and destroyed by fire; nor can the imagination create a more ghastly and desolate prospect than is produced by the constant sight of square mile after square mile of this bleached and ghostly timber. The destruction of the eucalyptus is necessary, however, in preparing the soil for cultivation, or even for the purpose of grazing sheep thereon, since little or no grass will grow beneath its branches. Once cleared, however, the land demonstrates great potentialities, and if water for irrigation purposes were everywhere available, the great interior plains of Australia would soon rival in fertility the finest districts of Southern California. Lack of water, however, forbidding Australia's rapid development agriculturally, vast areas of the interior are given up to sheep, and, in some particularly favored districts, cattle raising, with surprisingly successful results.

The great sheep "stations," or ranches, of Australia are among the most remarkable features of the country. The late millionaire, "Old Jimmie Tyson," as he was generally known, used to pasture seventy thousand head of cattle on a single one of his Queensland properties, and owned sheep stations in this colony and New South Wales each of which is larger than Bavaria. It is a common thing to ride in a straight line for fifty miles in Australia within the confines of a single property, and I have myself stood on the border-line between two stations—both owned by one man—which together exceeded Belgium in area. These enormous stretches of country are necessary for the proper feeding of the sheep, especially in the seasons of drought which are only too common incidents in the experience of colonial shepherds. The sparseness of grass, even in its best estate, is a revelation to the visitor, who is surprised to learn that some of the best sheep-growing country in Australia will carry but one sheep to the acre. The grass, springing to the height of one's knee during a few days of the autumn rains, rapidly withers under the intense dry heat of summer, and covers the ground with what seems a powdery kind of thin hay, which, however, has decided nutritive qualities for sheep, although any other animal would starve upon it. In former days a dry season often saw the death of twenty thousand sheep upon a single run; now, however, advantage is taken of a particularly fat year to store the superabundance of grass in ensilage and fodder pits, thus providing against possible danger in the future. Despite the gold and silver output of the country, more millionaires have, doubtless, been made by the sheep and wool industry; annual incomes of $50,000 and upward are common, and one pastoral "king," who owns some thirty stations in Victoria, Queensland and New South Wales, informed me that his net profit in 1890 was, in American money, $946,000. The importance of the wool industry to Australia is shown by the fact that the sheep and land upon which they are pastured are valued at not less than $2,500,000,000. The weights of Australian fleeces are phenomenal; those weighing six pounds when scoured are common, and some are recorded of nearly twice that weight.

Life on an Australian station is exceedingly novel and interesting. Many of the station-owners reside in substantial stone houses, which are equipped with all modern conveniences and often luxuriously furnished; their children enjoy education in England, France or Germany, and although the homestead may be a hundred miles from the railway and fifty from the nearest neighbor, the freedom of existence on the broad plains has in it much to compensate for its isolation. The family is more likely than not to spend the winters in Melbourne or Sydney, the station being carried on meanwhile by a manager, and a trip "home," as England is always referred to, is undertaken every few years. Visitors are received at these stations with a cordiality unmatched in any other part of the world; whether introduced or not, any tourist of refinement and discretion is warmly welcomed, and is at liberty to stay as long as he chooses. During his sojourn everything about the house or station is at his service; horses, traps, guns, fishing-tackle, all are indicated to him as his property for the time being. Should he wear out his welcome—and I have known one instance where a self-invited guest remained at a Victorian station for two years—he never learns of it, and indeed persons from the outside world are sufficiently rare to be welcomed warmly and separated from with regret.

The stranger who is fond of out-door life can have few dull moments on an Australian station, particularly if he is there during the shearing season. On a large station a hundred or so shearers may be encountered, most of whom are professionals, members of that army of nomads which, starting from the hot districts of Northern Queensland in February (a month corresponding to August in the Northern Hemisphere), spreads slowly down the country until it finishes its work in New South Wales and Victoria, nine months later. When the season is over they slowly work their way northward again, and are ready for another year's labor and travel. An interesting feature of station life in North Queensland is found in the gathering together of vast herds of cattle, which are then slowly "overlanded," or driven across the country, to Melbourne or Sydney, a distance, in some cases, of three thousand miles, to cover which some eight or nine months are required.

Of out-door sports the stations afford great variety. On the plains there is kangaroo-running, and coursing with the great hares of the country for the quarry; along the lakes and rivers there is abundance of wild fowl shooting, while if other game fails, there are always the omnipresent rabbits to fall back upon. Official reports of the extent of the rabbit pest in Australia read like travelers' tales; it may be enough to say that the average annual expense of the three principal colonies of Australia, New Zealand and Tasmania, simply to keep the animals within bounds, is over $3,500,000. All this trouble came from the introduction into the country of seventeen rabbits of assorted sexes, by Mr. Austin, a wealthy station owner near Geelong, Victoria, who was homesick for England, and thought the sight of a few familiar "bunnies" skipping about his acres would alleviate the malady. The prescription, as he himself told me, had cost him in forty years over $250,000, while the amounts represented by the losses of station owners generally on this account are simply incalculable.

The wholesale slaughter of kangaroos for their valuable hides has resulted in the practical extinction of these remarkable animals except in the remoter regions of the country, and most visitors make their only experience of Australia's typical quadrupeds in the zoological gardens of the principal cities. In the "back blocks," as the interior parts of Australia are called, they are still to be found in considerable numbers, and afford exciting sport to the hunter. The tribe of Australian kangaroos includes, besides these animals proper, a constantly dwindling succession of related species, wallaroos, wallabies, paddymeloos, and so on, ending with the diminutive and dainty kangaroo rat, which is often domesticated and makes a most interesting pet.

Retiring with the kangaroos and other specimens of the indigenous fauna of Australia, and, like them, gradually disappearing from the face of the earth, are the "blackfellows," or native inhabitants. The casual visitor sees very little of these singular people outside the battered, besotted specimens which hang around the small settlements, or perform the lowest and most menial work in this or that station stable. The major part of them have retreated before the white man into the interior, where they live a nomadic life, wandering hither and thither as the abundance or scarcity of their food compels them. They are the most degraded of all the South Sea peoples, building no shelters; having no arts of manufacture or decoration, in which the Maoris of New Zealand, the Fijians, Samoans, and others are so proficient; going about naked or only partly covered by the mangy skins of kangaroo or opossum, and securing their game either by rude throwing sticks or by spears made simply of a piece of straight wood pointed and hardened in the fire. The men are spare, wiry fellows, with skins resembling the color of a rusty stove, and heads with prominent, overhanging brows, and a covering of thick, matted hair on head and chin, which has a decidedly reddish cast of color. Their women are fat, oleaginous, with low foreheads and small eyes, narrow chests, and unsightly pendulous bosoms.

In the more inaccessible districts the blackfellows are as deadly and treacherous as an American Apache, and one can hardly follow the newspapers for a week without reading accounts of their murder of some defenseless squatter or shepherd. These outrages are, however, practically confined to Northern Queensland and West Australia, where the natives still practise cannibalism and other atrocities; in the other colonies they have been generally gathered into the government mission stations, where they are considerately treated and taught some of the principles of civilization—by which, however, it must be said, they show neither inclination nor ability to profit.

After nearly a century and a quarter of experience as a part of the colonial system of Great Britain, Australia begins the new century as a Federated Commonwealth, with the reins of government in its own hands. The future history of the country will be watched with interest, and time may fairly be expected to add here a new member to the sisterhood of nations. The new régime opens under favorable auspices; the first Governor-General, the Earl of Hopetown, has already had experience, and made himself exceedingly popular, as governor of Victoria; he has tact, resolution, intelligence, and large private means—the new commonwealth could not begin its life under more favorable auspices than seem to attend upon it at present.

In one of the districts of Vienna a local board of health has placed a placard which directs women who visit the park to hold up their skirts, if they are long enough to trail upon the ground.

GATHERING SHEEP FOR THE SHEARING.

[Continued from SUPPLEMENT, No. 1293, page 20730.]

OPENING ASTRONOMICAL ADDRESS.

By Dr. A. A. COMMONS, F.R.S., F.R.S.A., Chairman of the Department of Astronomy, Bradford Meeting of the British Association.

I PROPOSE to consider the question of the telescope on the following lines: (1) The refractor and reflector from their inception to their present state. (2) The various modifications and improvements that have been made in mounting these instruments. And (3) the instrument that has lately been introduced by a combination of the two, refractor and reflector, a striking example of which exists now at the Paris Exposition.

At a meeting of the British Association held nearly half a century ago (1853, Belfast), Sir David Brewster showed a plate of rock crystal worked in the form of a lens which had been recently found in Nineveh. Sir David Brewster asserted that this lens had been destined for optical purposes, and that it never was a dress ornament.

That the ancients were acquainted with the powers of a magnifying lens may be inferred from the delicacy and minuteness of the incised work on their seals and intaglios, which could only have been done by an eye aided by a lens of some sort.

There is, however, no direct evidence that the ancients were really acquainted with the refracting telescope, though Aristotle speaks of the tubes through which the ancients observed distant objects, and compares their effect to that of a well from the bottom of which the stars may be seen in daylight ("De Gen. Animalium," lib. v.) As an historical fact without any equivocations, however, there is no serious doubt that the telescope was invented in Holland.

The honor of being the originator has been claimed for three men, each of whom has had his partisans. Their names are Metius, Lippershey and Janssen.

Galileo himself says that it was through hearing that some one in France or Holland had made an instrument which magnified distant objects that he was led to inquire how such a result could be obtained.

The first publisher of a result or discovery, supposing such discovery to be honestly his own, ranks as the first inventor, and there is little doubt that Galileo was the first to show the world how to make a telescope (Newcomb's "Astronomy," p. 108). His first telescope was made while on a visit to Venice, and he there exhibited a telescope magnifying three times; this was in May, 1609. Later telescopes which emanated from the hands of Galileo magnified successively four, seven and thirty times. This latter number he never exceeded.

Greater magnifying power was not attained until Kepler explained the theory and some of the advantages of the telescope made of two convex lenses in his "Catoptrics" (1611). The first person to actually apply this to the telescope was Father Scheiner, who describes it in his "Rosa Ursina" (1630), and William Gascoigne was the first to appreciate practically the chief advantages by his invention of the micrometer and application of telescopic sights to instruments of precision.

It was, however, not until about the middle of the seventeenth century that Kepler's telescope came to be nearly universal, and then chiefly because its field of view exceeded that of the Galilean.

The first powerful telescopes were made by Huyghens, and with one of these he discovered Titan (Saturn's brightest satellite); his telescopes magnified from forty-eight to ninety-two times, were about 2¼ inches aperture, with focal lengths ranging from 12 to 23 feet. By the aid of these he gave the first explanation of Saturn's ring, which he published in 1659.

Huyghens also states that he made object-glasses of 170 feet and 210 feet focal length; also one 300 feet long, but which magnified only 600 times; he also presented one of 123 feet to the Royal Society of London.

Auzout states that the best telescopes of Campani at Rome magnified 150 times, and were of 17 feet focal length. He himself is said to have made telescopes of from 300 to 600 feet focus, but it is improbable that they were ever put to practical use. Cassini discovered Saturn's fifth satellite (Rhea) in 1672, with a telescope made by Campani, magnifying about 150 times, while later, in 1684 he added the third and fourth satellites of the same planet to the list of his discoveries.

Although these telescopes were unwieldy, Bradley, with his usual persistency, actually determined the diameter of Venus in 1722 with a telescope of 212 feet focal length.

With such cumbersome instruments many devices were invented of pointing these aerial telescopes, as they were termed, to various parts of the sky. Huyghens contrived some ingenious arrangements for this purpose, and also for adjusting and centering the eyepiece, the object-glass and eye-piece being connected by a long braced rod.

It was not, however, until Dolland's invention of the achromatic object-glass in 1757–58 that the refracting telescope was materially improved, and even then the difficulty of obtaining large blocks of glass free from strie limited the telescope as regards aperture, for even at the date of Airy's report we have seen that 12 inches was about the maximum aperture for an object-glass.

The work of improving glass dates back to 1784, when Guinand began experimenting with the manufacture of optical flint glass.

He conveyed his secrets to the firm of Fraunhofer and Utzschneider, whom he joined in 1805, and during the period he was there they made the 9·6 inches object glass for the Dorpat telescope.

Merz and Mädler, the successors of Fraunhofer, carried out successfully the methods handed down to them by Guinand and Fraunhofer.

Guinand communicated his secrets to his family before his death in 1823, and they entered into partnership with Bontemps. The latter afterward joined the firm of Chance Brothers, of Birmingham, and so some of Guinand's work came to England.

At the present day MM. Feil, of Paris, who are direct descendants of Guinand, and Messrs. Chance Brothers, of Birmingham, are the best known manufacturers of large disks of optical glass.

It is related in history that Ptolemy Euergetes had caused to be erected on a lighthouse at Alexandria a piece of apparatus for discovering vessels a long way off; it has also been maintained that the instrument cited was a concave reflecting mirror, and it is possible to observe with the naked eye images formed by a concave mirror, and that such images are very bright.

Also the Romans were well acquainted with the concentrating power of concave mirrors, using them as burning mirrors, as they were called. The first application of an eye lens to the image formed by reflection from a concave mirror appears to have been made by Father Zucchi, an Italian Jesuit. His work was published in 1652, though it appears he employed such an instrument as early as 1616. The priority, however, of describing, if not making, a practical reflecting telescope belongs to Gregory, who, in his "Optica Promota," 1663, discusses the forms of images of objects produced by mirrors. He was well aware of the failure of all attempts to perfect telescopes by using lenses of various curvature, and proposed the form of reflecting telescope which bears his name.

Newton, however, was the first to construct a reflecting telescope, and with it he could see Jupiter's satellites, etc. Encouraged by this, he made another of 6½ inches focal length, which magnified thirty-eight times, and this he presented to the Royal Society on the day of his election to the Society in 1671.

To Newton we owe also the idea of employing pitch, used in the working of the surfaces.

A third form of telescope was invented by Cassegrain in 1672. He substituted a small convex mirror for the concave mirror in Gregory's form, and thus rendered the telescope a little shorter.

Short also, from 1730–68, displayed uncommon ability in the manufacture of reflecting telescopes, and succeeded in giving true parabolic and elliptic figures to his specula, besides obtaining a high degree of polish upon them. In Short's first telescopes the specula were of glass, as suggested by Gregory; but it was not until after Liebig's discovery of the process of depositing a film of metallic silver upon a glass surface from a salt in solution that glass specula became almost universal, and thus replaced the metallic ones of earlier times.

Shortly after the announcement of Liebig's discovery, Steinheil (Gaz. Univ. d'Augsburg, March 24, 1856), and later, independently, Foucault (Comptes Rend., vol. xliv., February 1857), proposed to employ glass for the specula of telescopes, and, as is well known, this is done in all the large reflectors of today.

I now propose to deal with the various steps in the development of the telescope, which have resulted in the three forms that I take as examples of the highest development at the present time. These are the Yerkes telescope at Chicago, my own 5-foot reflector, and the telescope recently erected at the Paris Exposition, dealing not only with the mountings, but with the principles of construction of each. When the telescope was first used, all could be seen by holding it in the hand. As the magnifying power increased, some kind of support would become absolutely necessary, and this would take the form of the altitude and azimuth stand, and the motion of the heavenly bodies would doubtless suggest the parallactic or equatorial movement, by which the telescope followed the object by one movement of an axis placed parallel to the pole. This did not come, however, immediately. The long focus telescopes of which I have spoken were sometimes used with a tube, but more often the object-glass was mounted in a long cell and suspended from the top of a pole, at the right height to be in a line between the observer and the object to be looked at; and it was so arranged that by means of a cord it could be brought into a fairly correct position. Notwithstanding the extreme awkwardness of this arrangement, most excellent observations were made in the seventeenth century by the users of these telescopes. Then the achromatic telescope was invented and mechanical mountings were used, with circles for finding positions, much as we have them now. I have already mentioned the rivalry between the English and German forms of mountings, and Airy's preference for the English form. The general feeling among astronomers has, however, been largely in favor of the German mounting for refractors, due, no doubt, to a great extent, to the enormous advance in engineering skill. We have many examples of this form of mounting. A list of the principal large refracting and reflecting telescopes now existing is given at the end of this paper. All the refractors in this list, with the exception of the Paris telescope of 50 inches, and the Greenwich telescope of 28 inches, are mounted on the German form. Some of these carry a reflector as well, as, for instance, the telescope lately presented to the Greenwich Observatory by Sir Henry Thompson, which, in addition to a 26-inch refractor, carries a 30-inch reflector at the other end of the declination axis, such as had been previously used by Sir William Huggins and Dr. Roberts; the last, and perhaps the finest, example of the German form being the Yerkes telescope at Chicago.

The small reflector made by Sir Isaac Newton, probably the first ever made, and now at the Royal Society, is mounted on a ball, gripped by two curved pieces, attached to the body of the telescope, which allows the telescope to be pointed in any direction. We have not much information as to the mounting of early reflectors. Sir William Herschel mounted his 4-foot telescope on a rough but admirably-planned open-work mounting, capable of being turned round, and with means to tilt the telescope to any required angle. This form was not very suitable for picking up objects or determining their position, except indirectly; but for the way it was used by Sir William Herschel it was most admirably adapted; the telescope being elevated to the required angle, it was left in that position, and became practically a transit instrument. All the objects passing through the field of view (which was of considerable extent, as the eye-piece could be moved in declination) were observed, and their places in time and declination noted, so that the positions of all these objects in the zone observed were obtained with a considerable degree of accuracy. It was on this plan that Sir John Herschel made his general catalogue of nebulæ, embracing all the nebulæ he could see in both hemispheres; a complete work by one man that is almost unique in the history of astronomy.

Sir William Herschel's mounting of his 4-foot reflector differs in almost every particular from the mountings of the long focus telescopes we have just spoken of. The object-glass was at a height, the reflector was close to the ground. There was a tube to one telescope, but not to the other. The observer in one case stood on the ground, in the other he was on a stage at a considerable elevation. One pole sufficed with a cord for one; a whole mass of poles, wheels, pulleys and ropes surrounded the other. In one respect only were they alike—they both did fine work.

Lassell seems to have been the first to mount a reflector equatorially. He, like Herschel, made a 4-foot telescope, and this he mounted in this way. Lord Rosse mounted his telescopes somewhat after the manner of Sir William Herschel. The present Earl has mounted a 3-foot equatorially.

A 4-foot telescope was made by Thomas Grubb for Melbourne, and this he mounted on the German plan. The telescope being a Cassegrain, the observer is practically on the ground level. A somewhat similar instrument exists at the Paris Observatory. Lassell's 4-foot was mounted in what is called a fork mounting, as is also my own 5-foot reflector, and this in some ways seems well adapted for reflectors of the Newtonian kind.

We now come to the Paris telescope. This is really the result of the combination of a reflector and a refractor. I cannot say when a plane mirror was first used to direct the light into a telescope for astronomical purposes. It seems first to have been suggested by Hooke, who, at a meeting of the Royal Society, when the difficulty of mounting the long focus lenses of Huyghens was under discussion, pointed out that all difficulties would be done away with if, instead of giving movement to the huge telescope itself, a plane mirror were made to move in front of it (Lockyer, "Stargazing," p. 458).

The Earl of Crawford, then Lord Lindsay, used a heliostat to direct the rays from the sun, on the occasion of the transit of Venus, through a lens of 40 feet focal length, in order to obtain photographs, and it was also largely used by the American observers on the same occasion.

Monsieur Loëwy at Paris proposed in 1871 a most ingenious telescope made by a combination of two plane mirrors and an achromatic object-glass, which he calls a Coudé telescope, which has some most important advantages. Chief among these are that the observer sits in perfect comfort at the upper end of the polar axis, whence he need not move, and by suitable arrangements he can direct the telescope to any part of the visible heavens. Several have been made in France, including a large one of 24 inches aperture, erected at the Paris Observatory, and which has already made its mark by the production of perhaps the best photographs of the moon yet obtained. I have already spoken of Lord Lindsay and his 40-foot telescope, fed, as it were, with light from a heliostat. This is exactly the plan that has been followed in the design of the large telescope in the Paris Exhibition. But in place of a lens of 4 inches aperture and a heliostat a few inches larger, the Paris telescope has a plane mirror of 6 feet and a lens exceeding 4 feet in diameter, with a focal length of 186 feet. The cost of a mounting on the German plan and of a dome to shelter such an instrument would have been enormous. The form chosen is at once the best and cheapest. One of the greatest disadvantages is that from the nature of things it cannot take in the whole of the heavens. The heliostat form of mounting of the plane mirror causes a rotation of the image in the field of view, which in many lines of research is a strong objection. There is much to be said on the other side. The dome is dispensed with, the tube, the equatorial mounting and the rising floor are not wanted. The mechanical arrangements of importance are confined to the mounting of the necessary machinery to carry the large plane mirror and move it round at the proper rate. The telescope need not have any tube (that to the Paris telescope is, of course, only placed there for effect), as the flimsiest covering is enough if it excludes false light falling on the eye-end; and, more important than all, the observer sits at his ease in the dark chamber. This question of the observer, and the conditions under which he observes, is a most important one as regards both the quality and quantity of the work done.

We have watched the astronomer first observing from the floor level, then mounted on a high scaffold like Sir William Herschel, Lassell and Lord Rosse; then starting again from the floor level and using the early achromatic telescope; then, as this grew in size, climbing up on observing chairs to suit the various positions of the eye-end of the telescope, as we see in Mr. Newall's great telescope; then brought to the floor again by that excellent device of Sir Howard Grubb, the rising floor. This is in use with the Lick and the Yerkes telescopes, where the observer is practically always on the floor level, though constant attention is needed, and the circular motion has to be provided for by constant movement, to say nothing of the danger of the floor going wrong. Then we have the ideal condition, as in the Equatorial Coudé at the Paris Observatory, where the observer sits comfortably sheltered and looks down the telescope, and from this position can survey the whole of the visible heavens. The comfort of the observer is a most important matter, especially for the long exposures that are given to photographic plates, as well as for continued visual work. In such a form of telescope as that at Paris the heliostat form of mounting the plane mirror is most suitable, notwithstanding the rotation of the image. But there is another way in which a plane mirror can be mounted, and that is on the plan first proposed by Auguste many years ago, and lately brought forward again by Mons. Lippman, of Paris, and that is by simply mounting the plane mirror on a polar axis and parallel therewith, and causing this mirror to rotate at half the speed of the earth's rotation. Any part of the heavens seen by any person reflected from this mirror will appear to be fixed in space, and not partake of the apparent movement of the earth, so long as the mirror is kept moving at this rate. A telescope, therefore, directed to such a mirror can observe any heavenly body as if it were in an absolutely fixed position so long as the angle of the mirror shall not be such as to make the reflected beam less than will fill the object-glass. There is one disadvantage in the cœlostat, as this instrument is called, and that is its suitability only for regions near the equator. The range above and below, however, is large enough to

include the greater portion of the heavens, and that portion in which the solar system is included. Here the telescope must be moved in azimuth for different portions of the sky, as is fully explained by Prof. Turner in vol. lvi. of the Monthly Notices, and it therefore becomes necessary to provide for moving the telescope in azimuth from time to time as different zones above or below the equator are observed. No instrument yet devised is suitable for all kinds of work, but this form, notwithstanding its defects, has so many and such important advantages that I think it will obviate the necessity of building any larger refractors on the usual models. The cost of producing a telescope much larger than the Yerkes on that model, in comparison with what could be done on the plan I now advocate, renders it most improbable that further money will be spent in that way. It may be asked, What are the lines of research which could be taken up by a telescope of this construction, and on what lines should the telescope be built? I will endeavor to answer this. All the work that is usually done by an astronomical telescope, excepting very long continued observations, can be equally well done by the fixed telescope. But there are some special lines for which this form of research is admirably suited, such as photographs of the moon, which would be possible with a reflecting mirror of, say, 200 feet focal length, giving an image of some 2 feet diameter in a primary focus, or a larger image might be obtained either by a longer focus mirror or by a combination. It might even be worth while to build a special cœlostat for lunar photography, provided with an adjustment to the polar axis and a method of regulating the rate of clock to correct the irregular motion of the moon, and thus obtain absolutely fixed images on the photographic plate.

The advantage of large primary images in photography is now fully recognized. For all other kinds of astronomical photography a fixed telescope is admirably adapted; and so with all spectroscopic investigations, a little consideration will show that the conditions under which these investigations can be pursued are almost ideal. As to the actual form such a construction would take, we can easily imagine it. The large mirror mounted as a cœlostat in the center; circular tracts round this center, on which a fan-shaped house can be traveled round to any azimuth, containing all the necessary apparatus for utilizing the light from the large plane mirror, so as to be easily moved round to the required position in azimuth for observation. In place of a fan-shaped house movable round the plane mirror, a permanent house might encircle the greater portion round the mirror, and in this house the telescope or whatever optical combination is used might be arranged on an open framework, supported on similar rails, so as to run round to any azimuth required. The simplicity of the arrangement and the enormous saving in cost would allow in any well-equipped observatory the use of a special instrument for special work. The French telescope has a mirror about 6 feet in diameter and a lens of about 4 feet. This is a great step in advance over the Yerkes telescope, and it may be some time before the glass for a lens greater than 50 inches diameter will be made, as the difficulty in making optical glass is undoubtedly very great. But with the plane mirror there will be no such difficulty, as 6 feet has already been made; and so with a concave mirror there would be little difficulty in beginning with 6 feet or 7 feet. The way in which the mirror would be used, always hanging in a band, is the most favorable condition for good work, and the absence of motion during an observation, except of course that of the plane mirror (which could be given, by floating the polar axis and suitable mechanical arrangements, a motion of almost perfect regularity).

One extremely important thing in using silver or glass mirrors is the matter of resilvering from time to time. Up to quite recently the silvering of my 5-foot mirror was a long, uncertain, and expensive process. Now we have a method of silvering mirrors that is certain, quick, and cheap. This takes away the one great disability from the silver or glass reflecting telescope, as the surface of silver can now be renewed with greater ease and in less time than the lenses of a large refracting telescope could be taken out and cleaned. It may be that we shall revert to speculum metal for our mirrors, or use some other deposited metal on glass; but even as it is we have the silvered glass reflector, which at once allows an enormous advance in power. To do justice to any large telescope it should be erected in a position, as regards climate, where the conditions are as favorable as possible.

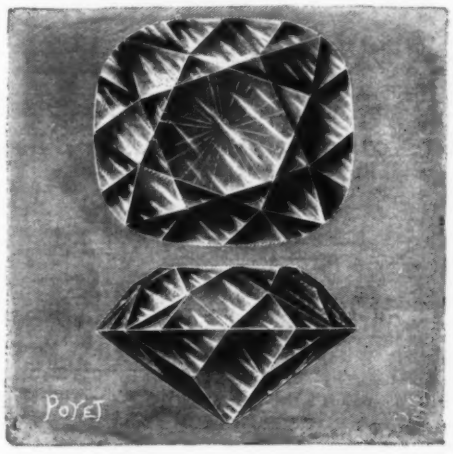
The invention of the telescope is to me the most beautiful ever made. Familiarity both in making and in using has only increased my admiration. With the exception of the microphone of the late Prof. Hughes, which enabled one to hear otherwise inaudible sounds, sight is the only sense that we have been able to enormously increase in range. The telescope enables one to see distant objects as if they were at, say, one five-thousandth part of their distance, while the microscope renders visible objects so small as to be almost incredible. In order to appreciate better what optical aid does for the sense of sight, we can imagine the size of an eye, and therefore of a man, capable of seeing in a natural way what the ordinary eyes see by the aid of a large telescope, and on the other hand, the size of a man and his eye that could see plainly small objects as we see them under a powerful microscope. The man in the first case would be several miles in height, and in the latter he would not exceed a very small fraction of an inch in height.

Photography also comes in as a further aid to the telescope, as it may possibly be to the microscope. For a certain amount of light is necessary to produce sensation in the eye. If this light is insufficient nothing is seen; but owing to the accumulative effect of light on the photographic plate, photographs can be taken of objects otherwise invisible, as I pointed out years ago, for in photographs I took in 1883 stars were shown on photographic plates that I could not see in the telescope. All photographs, when closely examined, are made up of a certain number of little dots, as it were in the nature of stippling, and it is a very interesting point to consider the relation of the size and separation of these dots that form the image and the rods and cones of the reckoner which determines the power of the eye.

Many years ago I tried to determine this question. I first took a photograph of the moon with a telescope of very short focus (as near as I could get it to the focus of the eye itself, which is about half an inch). The resulting photograph measured one two-hundredth of an inch in diameter, and when examined again with a microscope showed a fair amount of detail, in fact, very much as we see the moon with the naked eye; making a picture of the moon by hand on such a scale that each separate dot of which it was made corresponded with each separate sensitive point of the retina employed when viewing the moon without optical aid, I found on looking at this picture at the proper distance, that it looked exactly like a real moon. In this case the distance of the dots was constant, making them larger or smaller, forming the light or shade of the picture.

I did not complete these experiments, but as far as I went I thought that there was good reason to believe that we could in this way increase the defining power of the eye. It is a subject well worthy of further consideration.

I know that in this imperfect and necessarily brief address I have been obliged to omit the names of many workers, but I cannot conclude without alluding to the part that this Association has played in fostering and aiding Astronomy. A glance through the list of money grants shows that the help has been most liberal. In my youth I recollect the great value that was put on the British Association Catalogue of Stars; we know the help that was given in its early days to the Kew Observatory; and the Reports of the Association show the great interest that has always been taken in our work. The formation of a separate Department of Astronomy is I hope a pledge that this interest will be continued, to the advantage of our science.



THE "JUBILEE" DIAMOND—FACE AND PROFILE. (Actual size.)

LIST OF LARGE TELESCOPES IN EXISTENCE IN 1900.

Refractors 15 inches and upward.	Inches.
Paris (Exhibition)	50·0
Yerkes	40·0
Lick	36·0
Pulkowa	30·0
Nice	29·9
Paris	28·9
Greenwich	28·0
Vienna	27·0
Washington, U. S.	26·0
Leander McCormick Observatory, Virginia	26·0
Greenwich	26·0
Newall's, Cambridge	25·0
Cape of Good Hope	24·0
Harvard	24·0
Princeton, N. J., U. S.	23·0
Mount Etna	21·8
Strasburg	19·1
Milan	19·1
(Dearborn) Chicago	18·5
Warner Observatory, Rochester, U. S.	16·0
Washburn Observatory, Madison, Wisconsin	15·5
Edinburgh	15·1
Brussels	15·1
Madrid	15·0
Rio Janeiro	15·0
Paris	15·0
Sir William Huggins	15·0
Paris	15·0

Reflectors 2 feet 6 inches and upward.	Feet.	Inches.
Lord Rosse	6	0
Dr. Common	5	0
Melbourne	4	0
Paris	4	0
Meudon	3	3
South Kensington	3	0
Crossley (Lick)	3	0
Greenwich	2	6
South Kensington	2	6

THE RUBBER INDUSTRY OF SIERRA LEONE.

THE Kewattia, or rubber tree of West Africa, is one of the most beautiful trees of the forest, growing usually to the height of from forty feet to sixty feet. Its leaves are from four to nine inches in length by from one to three inches in width, oblong and tapering toward the ends, supported by a stem from eight to nine inches long. There are several species of vines which yield a grade of rubber inferior in some respects to that obtained from the tree; however, when gathered with care this commands a ready sale. The United States consul in Sierra Leone says that the supply of Freetown market for the most part comes from the hinterlands of Sierra Leone and from the Foutah country in the French protectorate farther in the interior. That which comes from the Foutah territory is limited, owing to the export tax of about three half-pence per pound placed by the French upon all rubber sold by natives outside of their protectorate. Notwithstanding this prohibitory restriction upon the native rubber vendors, there are several regular traders who furnish to the market a good quantity of Foutah rubber every season. This rubber is almost invariably adulterated with clay, yet it grades well in the local market, and brings a good price. In former years Freetown was a better depot for rubber than at present, but since the establishment of the French protectorate, which controls the output of the valleys of the adjacent nothern rivers, the trade has been directed to the French port of Konakry, seventy-two miles distant from Freetown. The dry period from November until May is the gathering season. Native chiefs supervise and control the sale of the output of their respective territories. The method of gathering the sap is very simple. The body of the tree is tapped and the juice flows until it is exhausted; later, new incisions are made. The juice is usually caught in cups or calabashes attached to the tree, so as to prevent impurities appearing in the rubber. The neglect of this precaution is responsible for a percentage of the incidental adulterations of otherwise good rubber, frequently found in the local market. The native in his efforts to increase his stock frequently bleeds the roots as well as the body of the tree; this is fatal to the tree. The product is known as "root rubber," and besides containing large quantities of impurities, is very inferior to any grade of tree rubber, and would be refused altogether by local buyers, in order to discourage the destruction of the forests, were it not for the sharp competition for export trade. The rubber is brought to market overland by caravans of natives, or most frequently by canoes. These cargoes are generally consigned to some particular agent, though they are often sold to the one making the best offer. For convenience, rubber is arranged in three classes or grades, known as No. 1, No. 2, and No. 3, the character of the tissues and freedom from impurities being the determining factors, as well as the kind of adulterants. Considerable ability on the part of the agent is necessary to enable him to properly assort and select the rubber and to detect adulterations. There are two classes of these—incidental and intentional. The former is the result of carelessness on the part of the gatherers who do not use proper receptacles for the juice. Intentional adulterations are due to efforts to increase volume and weight by use of dirt, sand, bark, and sometimes stones. Another species of fraud is the mixture of other non-elastic gummy substances with pure juice; still another is to soak rubber by placing it in pits close to the water for a long time. Rubber so treated is seriously injured in quality, and at the same time increased in bulk and weight. The colonial authorities as well as the chambers of commerce are endeavoring, by proper instructions to those concerned, to discourage these abuses, and to emphasize in every way possible the importance of improving the quality of the rubber brought to Freetown market. There is being inaugurated by the governor and officials a plan to foster the planting of rubber trees and vines in the colony. To this end they have caused to be issued pamphlets of instructions in regard to seeding, transplanting, etc., through the departments of agriculture and horticulture. It is hoped that there will be a decided improvement in the quality and quantity of the exports in the near future. The value of the rubber exported from Sierra Leone in 1898 was about £51,000, of which the amount shipped to Germany was £6,700. The remainder went to England.

THE "JUBILEE" DIAMOND.

ONE of the classes of the Exposition that attracts the attention of the visitors most, and especially that of the female visitors, is undeniably that of jewelry. In the French section we see a series of ornaments of which the precious stones surprise us not only by their size and their brilliancy, but also by their number. Never at any epoch has there been seen so great a profusion of rich jewelry, the price of which would be represented by the respectable figure of millions of francs. It is dazzling to the eyes, a problem to the mind, and, let us add, a great success for French industry, which always keeps at the head when it is a question of showing qualities of good taste and elegance.

In one of the showcases we see the largest diamond in the world, and which its owners, who form a society, have named the "Jubilee." This unique stone exceeds all its predecessors, since, in addition to its great weight of 239 carats, it is of an absolute purity of water and its cutting presents no error. It is even so perfect and so regular that if it be placed upon the truncated point of its base it will hold itself in equilibrium. Not a cloud troubles the limpidity of its fire, and not a flaw diminishes its value. The faultless harmony of its proportions, and its almost supernatural brilliancy, which seems to engender light, both surprise and charm every beholder.

This phenomenal stone was found in the diamondiferous strata of Jagersfontein, near the city of Kimberley, in South Africa. This mine is, as well known, in the vicinity of the celebrated exploitations of De Beers.

In order to give an idea of its value, let us recall the fact that the finest diamonds known up to the present have been the "Regent," the "Orloff," the "Great Sancy," etc. The "Regent," which belongs to the state, weighs but 136 carats and has a slight flaw upon one of its edges; the "Orloff," which belongs to the Czar, weighs 193 carats, but its color is nearly yellow and its cutting is defective; the "Grand Sancy" weighs 53½ carats.

We have also the "Koh-i-Noor," which belongs to the crown of England and weighs 106 carats. Its color is slightly grayish.

To whom will the Jubilee belong? What crown prince or prince of finance will become the possessor of it? That is an enigma difficult to unravel. The value of diamonds, as we know, increases according to the geometrical progression 1, 4, 16, 64, etc.; so that if this rule were to be applied to the Jubilee, no existing sum could pay for it.—La Nature.

APPLICATIONS OF PETROLEUM TO METALLURGY AND THE GLASS INDUSTRY.

Although numerous tentatives have for a long time been made, principally in Russia, the United States, and England, to employ petroleum in a certain number of metallurgic operations, the rational use of this fuel has been rendered possible only through the improvements devised by Nobel. He, in fact, was the first who endeavored to effect the complete combustion of petroleum by means of a natural draught, and without the intervention of steam or compressed air for its vaporization. He thus succeeded, not only in preventing the production of smoke and soot, but also in raising the temperature of the furnace in such a way that pieces of soft iron contained in crucibles were sufficiently liquefied therein to be afterward cast.

As long ago as 1882, Nobel made a number of communications of the highest interest to the Imperial Technical Society of Russia assembled at Moscow, and one of these especially, relative to the use of petroleum

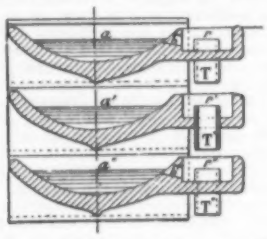


Fig. 1.—Details of the Grate.

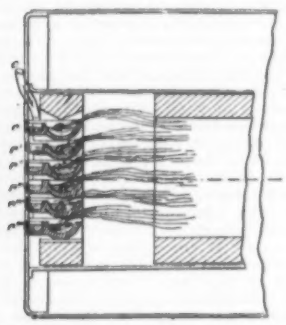


Fig. 2.—Longitudinal Section of a Furnace Provided with the Grate.

Figs. 1 and 2.—THE NOBEL GRATE FOR THE BURNING OF PETROLEUM.

in a large regenerator, described the fusion of a ton of iron with 145 pounds of petroleum residuum.

The Nobel Grate.—The characteristic innovation introduced by Nobel consisted in the arrangement and special form of the grate employed for the combustion of the petroleum.

This grate (Fig. 1) consists of a series of superposed troughs, a, a', a^2, containing the liquid fuel, the discharge of which is regulated by small basins, r, r', r^2, that communicate with the troughs at b, b'. Through the axis of the basins pass discharge pipes, T, T', T^2, open at each extremity. All the parts of the grate are of iron cast in a piece, and comprising no movable joint.

The petroleum is introduced through the tube, c (Fig. 2), of the tank into the upper basin, r (Fig. 1), whence it passes into the trough, a, the overflow discharging itself, through the pipe, T, into the basin, r', and so on; so that the petroleum has always a constant level in all the troughs.

If the discharge of the petroleum is too great with respect to the activity of the combustion, the excess of fuel overflows from the lower basin, r^2, into a special reservoir placed beneath the furnace. Finally, between each trough there is a space provided for the passage of the air. The petroleum does not burn in the small basins, but only in the troughs, in which the combustion is complete without the necessity of causing the intervention of steam or compressed air.

In order that the mixing of the air and gaseous hydrocarburets may be more intimate, a flue, o (Fig. 3), is arranged between the reverberatory and hearth, so

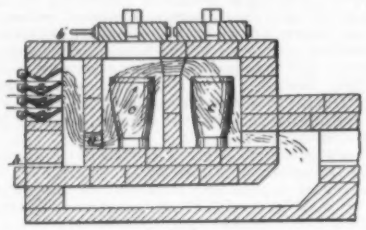


Fig. 3.—GENERAL ARRANGEMENT OF A NOBEL FURNACE.

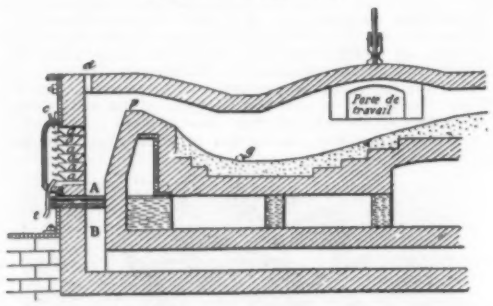


Fig. 4.—LONGITUDINAL SECTION OF A NOBEL REVERBERATORY FURNACE.

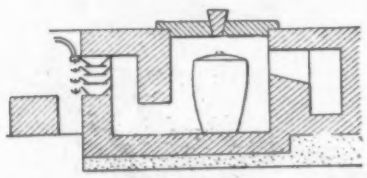


Fig. 5.—SECTION OF A NOBEL SMELTING FURNACE.

that the flames are forced to unite well before reaching the crucibles. In certain cases, it is also advantageous to introduce air back of the grate, so as to obtain the best conditions possible for combustion. Fig. 3 represents a vertical section of a furnace designed for the fusion of iron and steel in a crucible, and in which a, a', a^2 are the troughs of the grate; b, b', the air ports; o, the flue, and c the crucibles. In order to regulate the combustible well according to requirements, the air ports, b or b', are opened alternately.

Through these improved arrangements there is consumed, per square yard of grate and per hour, 249 pounds of petroleum residua. The fusion of one ton of pig iron, iron, or steel requires, respectively, but 0·125, 0·75, and 0·6 of a ton of petroleum residua, while it takes 0·5, 1·5 and 1 ton of coal to obtain the same result.

Experiments in vaporization made with the new grate have permitted of vaporizing as many as 6·5 quarts of water per pound of residua, instead of the 5 quarts vaporized through the use of the atomizer.

pipe through which passes the overflow of the basins; and d is the air port designed to regulate the combustion. The flame breaks against the fire bridge, p, before reaching the furnace bottom, which is composed of quartzy sand and clay. In case of stoppage of the work, the flame proceeds toward the flue, B, which is normally covered by a stone, A. The casting is effected through the tap hole, g.

The charge is put in, as usual, at the back of the furnace, and is made to advance progressively through the working holes.

This reverberatory furnace is constructed with a view to the production of 1,600 tons of cast iron. Upon the whole, it presents no other characteristic arrangement than that of the grate. The same is the case with the smelting furnace shown in diagram in Fig. 5. For the production of a ton of copper, this furnace consumes 0·625 of a ton of petroleum residua.

Since coal and wood are entirely wanting in the vicinity of Baku, much more study has been devoted in this region to the various industrial applications of heating by petroleum than elsewhere—in Pennsylvania, for example, where coal and wood abound. Besides, the yearly increase in the number of wells in the Caucasus has led to the establishment, in situ, of large manufactories, which are now producing the reservoirs and the metallic tanks that serve for storing the enormous quantity of petroleum that the Caucasus is annually yielding.

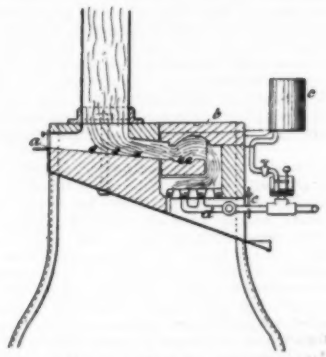


Fig. 6.—QUARNSTRÖM PORTABLE FORGE.

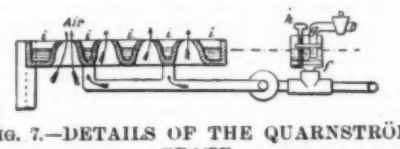


Fig. 7.—DETAILS OF THE QUARNSTRÖM GRATE.

The Quarnström Forge.—One of the most recent applications of heating by petroleum in the Caucasus is to forges, in which coal was for a long time employed. This innovation is due to Quarnström, who constructed a portable petroleum forge (Fig. 6) designed especially for the heating of rivets.

This forge occupies but little space and is so light that a boy can carry it. The rivets reach the necessary temperature therein very rapidly and without the aid of a bellows. The results obtained with it have been so satisfactory that it has been adopted in the works of the Nobel Brothers at St. Petersburg. The principle of the heating of this forge is the same as that of the Nobel grate, with the difference that the troughs are arranged therein in a horizontal plane. The petroleum reservoir, c, is entirely closed and mounted upon a lateral bracket.

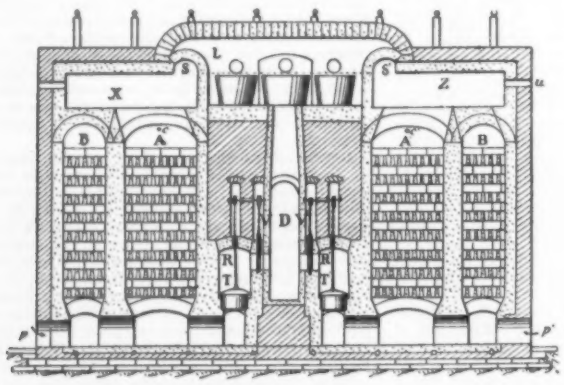


Fig. 8.—LONGITUDINAL SECTION OF THE KROUPSKY REGENERATOR.

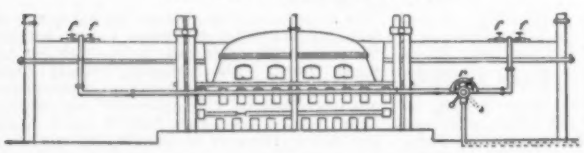
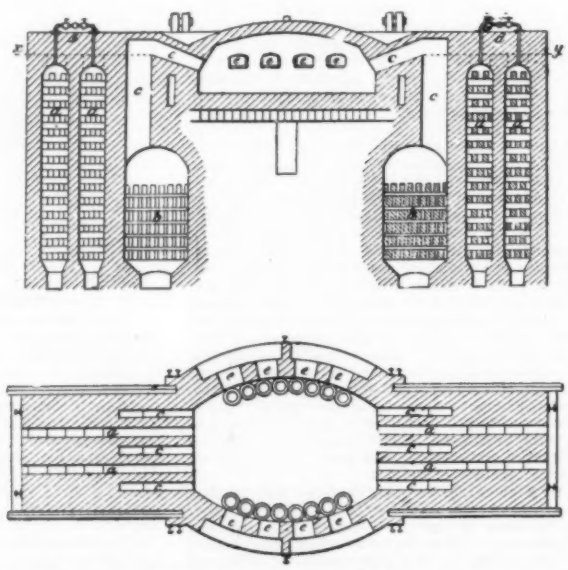


Fig. 11.—ELEVATION OF THE MALICHEFF FURNACE.



Figs. 9 and 10.—VERTICAL AND HORIZONTAL SECTIONS OF THE MALICHEFF FURNACE.

Applications of the Nobel Grate to Metallurgy.—The arrangement of grates with superposed troughs is now applied in the Nobel works of St. Petersburg and the Caucasus for the fusion of pig iron in reverberatory furnaces (Fig. 4) and for the fusion of copper in crucibles (Fig. 5).

The petroleum enters the troughs, a, of the reverberatory furnace (Fig. 4) through the pipe, c; t is the

The rivets are introduced through the door, a (Fig. 6); b is a movable cover, which is displaced in order to remove them from the forge; and e is the device that supports the burner, d. This latter (Fig. 7) consists of a row of receptacles, i, i, in which the liquid fuel is kept at a constant level through a small reservoir, f, which receives the inlet tube, g', fixed to the closed reservoir, c (Fig. 6). Finally, a small screw, h, permits.

if need be, of lowering or raising the tube, *g*. It will be readily seen that the fuel flowing into the reservoir, *f*, soon closes the aperture of the tube, *g*. The discharge is therefore suspended; but, since the combustion causes the level to lower in the receptacles, it is immediately resumed. It is in this way that the receptacles are kept at a constant level and a regular combustion is obtained.

In order to clean the burner, it suffices to unfasten it at *e*.

The production of soot is not abundant. In order to reduce the quantity of it as much as possible, the Baku works employ gasoline instead of the heavy hydrocarbons. The burner is covered with a plate of cast iron provided with hollowed projections. These latter do not fit into the receptacles tightly, for it is through the interstices left between the two that the flames and the gaseous products of combustion have to escape.

Applications of the Nobel Grate to the Furnaces of Glassworks.—Petroleum is likewise employed in Russia for heating the furnaces of glassworks. The hydrocarburets of petroleum, moreover, are adapted for the fusion of glass, which, as well known, requires particularly pure fuels.

The first experiments in this line were nevertheless not successful, since the heat developed in the interior of the furnaces was such that at the end of four or five days' work the vaults and flues gave way, and even the most refractory crucibles were incapable of withstanding it. It was then that the idea occurred to substitute regeneration of the heat for direct heating.

This idea was applied with success by Prof. Kroupsky, of Russia, who, for melting glass, constructed the petroleum-heated regenerator represented diagrammatically in Fig. 8. This furnace may be employed likewise in metallurgic operations. It comprises a series of chambers, *A*, *B*, *A'* and *B'*, fitted with refractory bricks arranged in open work. The petroleum enters at *A* and *A'* at a certain pressure, and is distributed alternately and at equal intervals by the blowpipes, *c* and *c'*, the orifices of which have a diameter three times less than that of the inlet tubes. The petroleum immediately becomes decomposed at the top of the chamber in contact with the incandescent bricks, and at the expense of the air introduced at *p*. It is evident that since the zone of combustion of the petroleum is circumscribed at the upper courses of bricks, no detonating mixture can form either in the furnace or in the compartment in which the combustion takes place.

Contrary to what is generally found in furnaces for the regeneration of heat, the bricks here have a trapezoidal section. Owing to this special form, the molecular vibrations engendered in the gaseous and inflamed mixture that passes between the bricks are very energetic and render the mixture of the liquid molecules of the petroleum and the combustible air as intimate as possible. The lower courses of bricks never receive any petroleum and serve only for heating the air. The dimensions of the refractory brick compartments are notably greater than those used in ordinary regenerators. The current of petroleum, which passes from *A* to *A'*, the chamber that has been previously strongly heated by the burned gases of the furnace, is reversed every half hour by a simple play of cocks. The airports, *p*, may be closed by means of doors that are opened alternately according as the combustion occurs in the chamber to the right or in that to the left. In alternately raising the iron plate registers, *T T'*, in an order reverse that of the air-ports, the gas of the furnace is directed into the chimney through the conduits, *R R'*. A pocket, *D*, is specially reserved for the dross or scum. Finally, in acting upon the valves, *V V'*, it is possible, when necessary, to cause a part of the flame to pass through the lateral flues toward the bottom of the crucibles by attracting it through the pocket, *D*, directly into the flues. The chambers, *A A'*, are provided at their upper part with a series of small arches, forming a grate, through which pass the inflamed gases before entering the furnace. Finally, these gases enter the fire-place, properly so called, after having met with a second series of arches, *S S'*.

It is unnecessary to say that these arches, as well as all the parts of the furnace to which they are contiguous, are always in an incandescent state in the chamber in which the combustion occurs. They are arranged with the object in view of rendering such combustion as complete as possible.

The chambers, *B B'*, are small regenerators in which a complement of hot air is made to enter. They likewise are covered with a grate formed of small arches, the order of which alternates with that of the elements that constitute the grate of the chambers, *A A'*. The sight holes, *o* and *u*, permit of watching the work of the flame in the conduits, *X* and *Z*, in which meet the superheated air and the inflamed gaseous mixture at its exit from *A* and *A'*.

In conclusion it is well to mention another equally happy attempt made in Russia to employ petroleum in the glass industry by means of furnaces of the Malicheff system.

In the construction of his furnace, M. Malicheff was influenced by the ordinary type of the Siemens regenerators. The vertical and horizontal sections and the elevation given in Figs. 9, 10, and 11 will suffice to allow the operation of it to be understood, after we have added that *a* and *a* are the chambers in which occurs the combustion of the petroleum introduced by the tubes, *ff* (Fig. 9) and *r* (Fig. 11). A meter serves to register the discharge and to reverse the current every twenty or thirty minutes. Finally, *b* and *b* are the hot air compartments.

The petroleum enters one of the chambers, *a*, which has been previously heated, and is converted into gas therein in contact with the incandescent bricks, which become progressively covered with a layer of coke representing the fixed residuum of the decomposition of the petroleum. As soon as the interstices between the bricks of a chamber are almost entirely closed, there is introduced a current of hot air, which immediately causes the complete combustion of the coke. This furnace seems to be very economical, and may have its *raison d'etre* even outside of petroleum-producing countries. It consumes, in fact, but 1·3 ton of petroleum residua for the production of 4 tons of glass, say 715 pounds of fuel per ton.

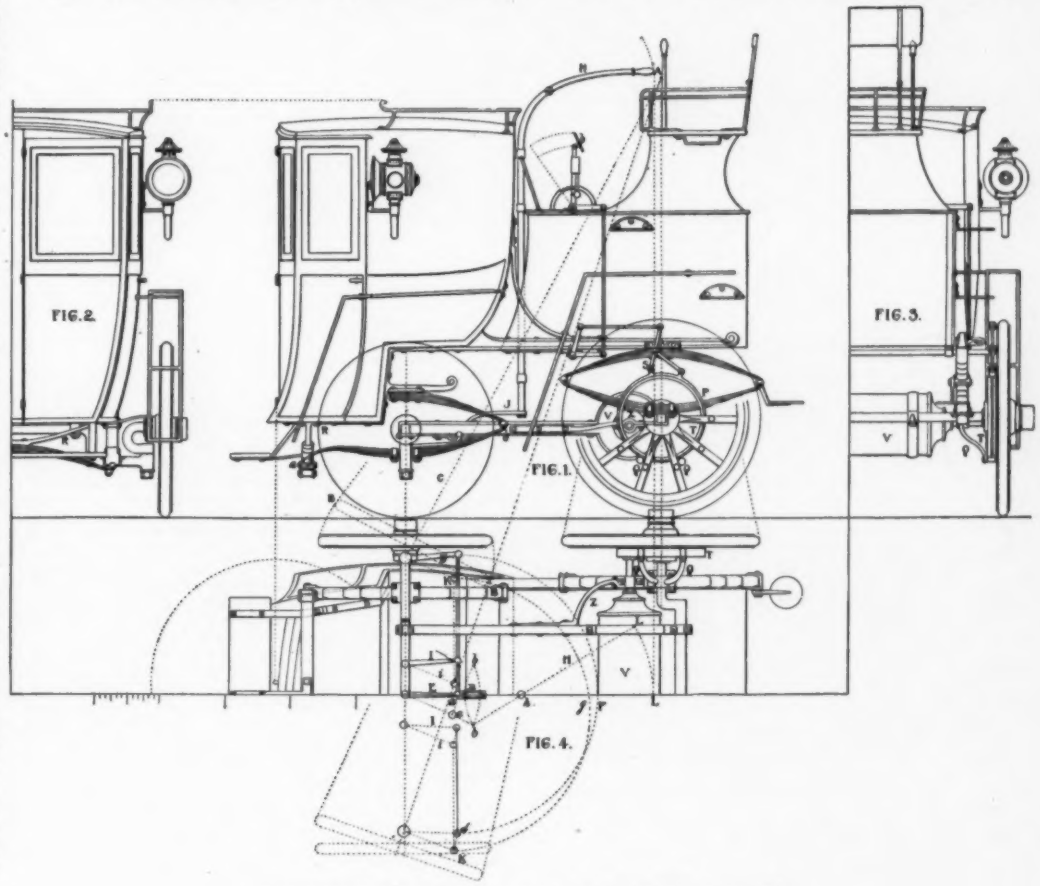
For the above particulars and the engravings, we are indebted to Le Génie Civil.

WORKING DRAWING OF ELECTRIC COUPE.

(Scale, ½ inch to the foot.)

THE working drawing of an electric coupé shows how to construct the body, battery box, and the gear in proportions to insure safety. The mechanic familiar with the peculiar features of this new kind of self-propelled carriage may see in our work suggestions applicable to the designs of his own. This will benefit him, as the proper way to reach perfection is to know all he possibly can of the methods employed in the mechanical part of building the electric coupé, both as to its design and details of putting together. The many changes which we introduce to our clients in the trade are conspicuous for their practicability, and go a long way toward attracting the attention of builders of motor carriages. It is, therefore, essential to a clear explanation of the coupé to first notice the changes which make this drawing of value as a contribution to the public eye. First, the design and hinging of the doors in the center of the round front, which permits the advanced position of the front wheel, as the door can be opened without striking the wheel, also allowing a large space, making a convenient entrance-way to the seat. The front part of the wing, being separate from the top portion, swings around with the door. When the door is open, the space from the lock to the hinge pillar is 26 inches, which gives all the space required for comfortable access and exit. In a public conveyance this is an important consideration. This mode of hanging the door is an important improvement, and a matter of economy in the time saved in building the body. It is easy to make and hang this door, but it is difficult to make and hinge the hansom cab doors, and still greater is the problem of opening and shutting them.

Second, the front axle is first dropped a distance of



WORKING DRAWING OF AN ELECTRIC COUPÉ.
Scale, ½ of an inch to a foot.

5¼ inches, to receive the three-quarter elliptic spring, and then again arched upward to receive the two perches. If we give the axle this angular shape (see Fig. 2), with the weight below the hub, then it will not, when the two perches are clipped on, 6 inches higher up, oscillate to and fro, as a swing. On the other hand, if the axle is straight across, then the perches must be lower at the front, and we lose the support to the spring which this leverage construction supplies. We pivot the arm to this axle, by first cutting a slow thread the length of the box, say in size four to the inch, then cutting a like thread on the stem of the wim-wam, right and left, and on the projecting end fit a hexagon nut, as shown in Fig. 2. We then curve the arm from this point to a circle to enter at right angles to the flared face of the wheel, and since the weight is below instead of above the center of the hub of the wheel, it is reasonable to suppose that the tendency of the axle, the spring, and the wheel, is to maintain this position while in motion. We assume that the weight of the side spring at *a* and *b* is equal. We know that this weight through the spring to axle will maintain the poise given to the arch of the axle.

Third, the steering gear, which directs the course of the carriage, turns the front wheels on their pivots to the angle represented in the projection, Fig. 4. In this instance we find the limit to which we may safely set the angle to be 63 degrees. To learn this we turn the wheel so that the tire nearly touches the side spring; next we prolong the line of the hind axle indefinitely; then if with the dividers we intersect this line from the two points of the tire, *B B*, Fig. 4, the line, *C*, will be a right line to the tire of the wheel and will cut the center of the pivot upon which the front wheel swings. Then the point, *A*, Fig. 1, becomes the center about which every other wheel must turn, stationed at a distance from the point band of the opposite front wheel in plan of 12 feet 8 inches, which doubled is 25 feet 4 inches, the space in which the carriage will turn. We learn from this that the longer the gear is coupled, the more space is required to turn the motor carriage. We understand that in the line of the hind axle is to be found that point about which all the other parts must revolve. We also understand from this that the point, *A*, can be found only in the plane of the hind axle, because every other of the three wheels is also square to this point. This becoming clear to the mind, we proceed to consider the connecting rods of the steering gear. Heretofore this object has been accomplished by a single rod reaching from one wim-wam arm to the other, with the pivot in the center, or with one arm longer than the other. The positions here shown will be repeated when the carriage is directed in an opposite way, so that in any position to which the wheels may be turned the cross rods will be parallel to each other, they will move in parallel lines, and if they do not it is a guarantee that when they do turn, one wheel or the other must slip. Furthermore, the four arms from axle to connecting rods will also be parallel to each other when turned about their respective centers, and they must be of equal length and of equal angle. Their position as to the center of the longitudinal axis is not imperative; they may, according to conditions, find their pivot on the front axle, either close or remote from that center. The drawing is easy to follow on this point. Let us fix the position of the arm, *D*, Fig. 4, to the axle, then from the center, *A*, describe the circle, *F*, fixing correctly the position of the opposite arm, *D*; then when the wheel is moved to a full lock station the arm in its new position, *K*, then from the center, *e*, of the arm, *E*, describe the circle, *g*; it will find the pivot and position of the arm, *d*, in the point, *k*. The central arms of the gear will take up their proper positions as shown in the plan, *I I*; *i i* and *h*, Fig. 4, indicates the plan center of the steering bar, *H*, Fig. 1. On the lower end is fixed a single prong, *J*, Fig. 1, the length of which is from *h* to *n* of the ellipse, *B b*, at which section a slot is cut to receive the bolt which fixes the prong, *J*, of the bar, *H*, to the arm, *E*. Then when the lever, *H*, is turned from *L* to *L* on the pivot, *h*, the end of the prong, *J*, will travel to *b*, the rod, *E*, to *C*, the arm, *D*, to *K*, and the wheel to *B B*, and the wheels are then locked. Anyone can, with a pair of dividers, test the correctness of the work, to ascertain the principle involved.

Fourth, the brake, termed a hub brake, because the power derived from the foot lever, *b*, Fig. 1, is impinged upon the driving cog, *P*, Fig. 1, by means of the several rods connected to the lever, all of which are in plain view in the finished carriage, which is the same upon the opposite side, and is operated upon from the center of the top of the battery box. The curved arms, *Q*, Figs. 3 and 4, support the steel band which encircles the disk of the cog, *P*, and at the same time hinges them in two equal sections. This band has a thickness of one-quarter of an inch; it has a circle when not fixed in position much greater than that of the cog wheel, *P*, so that when confined by the compressor, *S*, Fig. 1, it provides a spring to throw off the brake band when the foot lever, *b*, takes the position as in Fig. 1. The ends at the top between the pivots of the compressor overlap each other, to prevent dust from finding its way to the inside surfaces of the band, *P*. This obviates the need of other springs to take up the slack in throwing off the brake. If the brake at all parts is nicely filed and polished, fitted with brass fixtures, not painted, its appearance

will prove the good workmanship of the builders. In this exposed position the rods and connections are easily adjusted and easily repaired.

Lastly is the connecting of the motor shaft with the driving cog wheel, the teeth of which are on the inside of the band, or the periphery, because the outside surface is required for the brake. This cog wheel, *T*, shown in the three views, 1, 3, and 4, is bolted to the spokes of the hind wheel, as shown in Fig. 1.

The hind axle is cranked to make room for the motor, *V*, shown in the three views, Figs. 1, 3, and 4, and to make room for the perch coupling, composed of the top and bottom plates, which are made to encircle the motor cylinder, *V*. It is further strengthened by a coupling, *Z*, forged from the solid, with the spring coupling clip, shown in Figs. 1 and 4. A brace, *Z*, is then turned into the side of the perch and bolted. Here the work becomes complicated; it is crowded, and this spring coupling clip must be forged, with the support, *Z*, to fix the motor shaft close up, and to accomplish the work of turning the hind wheels by means of the one cog meshing with the other. When the carriage is moving ahead, the stress of the motor shaft on its supports is upward, the reverse when moving backward. This being true, we are to consider the stress on the hind axle, from either of the two mentioned directions. To either lower the crank portions of the axle, or raise it, will act directly, both against the armature of the motor cylinder and against the front axle. If it moves in either direction to the amount of one-sixteenth of an inch, it must move the motor that amount. It must also move the front axle the same, as it cannot move either and is a stiffer axle than if made straight. To make it straight across, the cylinder must be reduced or the drive wheel enlarged.

In the drawing of the side elevation we show the body, provided with pump-handles, extending to a coupling with the hind elliptics, also a spring bar. The battery caisson is bolted to this bar, also supported at the front by two iron bars, which in turn are bolted to solid forged lugs of the bottom plate of the pump handles. In this way we can make this compartment separate from the body, which is easier done and simpler than when made up solid, and easier handled in the shop departments, easier for the smith to iron, and the box need not be taken into the room to be trimmed. It will be seen that the paneling up of the body and box separate is less troublesome than if made up in one. The steering bar passes down through the open space, which, if solid, must either pass through or on the side of the box. The pump handles are a continuation of the rockers, and not the bottom sides; they extend through to the door pillar; the bottom sides are screwed against them.

The front step is made of hard wood, and runs across the front, and can be used from either side. The iron stays supporting the step are a continuation of the span bar, *R*, Figs. 1 and 2, as on this kind of work, where there is a multiplicity of stays and braces, it becomes necessary and also economical to make one iron answer for two or more purposes; in this way one supports the other; here the two ⅝-inch bolts answer all the requirements of both spring bar and step braces, as better seen, *R*, Fig. 1. Again we brace the center of the board step by a stay fixed at the bottom of the cross springs.

In the motor carriage the front wheels are pushed and not pulled along the road. The stress upon parts of the gear may, under certain conditions, be severe; for instance, when turning at full lock, the fore wheels may meet with either a hole or another obstruction. When this is the case, the perch and springs are both acted upon—the one above, the other below, the center of the wheel; evidently the front axle, the coupling of the wim-wam, are as strong as the power applied to the hind wheels, but with good roads these carriages can be made much lighter than they have been, and they may be heated and lighted by electricity.—The Hub.

AMERICAN SUN MYTHS.*

We find among all primitive people—particularly among the native tribes of North America—a considerable body of myths and traditions which refer to the heavenly bodies, more especially to the sun and moon. The number of these myths is very great, indeed; and we find them among all American tribes; for instance, among the Eskimo, one in which the sun and moon figure as brother and sister, the sister (the sun) running away from the moon, who is pursuing her and, in the course of the northing of the sun, reaching or overtaking her. In another case we have the tradition referring to the sun in which a certain animal makes a chain of arrows, shooting one arrow after another up to the sky; the first arrow striking the sky, the second one striking the first arrow, etc., until finally the chain is formed around which the animal climbs to the sun. There are others concerning evaporation and rainfall, wherein, generally, the story seems to turn something like this: that the father sun does not like the water—does not want him to marry the cloud; and, for this reason, he subjects him to a number of severe tests, trying to kill him; but eventually the water conquers, and the sun permits him to marry his daughter.

Naturally we look for an explanation of these traditions in the phenomena of nature. When we find, for instance, in the Eskimos, the moon reaching the sun, we see very clearly the idea connected with the phenomenon of solar eclipse. When, on the other hand, is found the tale of the sun reaching the western horizon and there being swallowed by some monster, it is quite natural that we interpret this monster as the darkness of night—interpret this whole myth as a limitation of the familiar phenomenon of sunset; and, in a similar way, we find explanations of the myths in the phenomenon of sunrise, etc. The temptation is strong to consider all traditions of this kind as attempts of primitive man to explain the phenomena of nature, particularly the phenomena referring to the course of the sun, and of the moon around the sun—phenomena referring to the seasons.

A careful analysis of the myths of American Indians, and also of other tribes, brings out the points that a great many of the elements which appear in our solar and lunar myths occur also in other traditions; for instance: the tale of the animal ascending to the sky along a chain of arrows and, on reaching the sky, marrying the daughter of the sun. This occurs in quite similar form, far away from America. In Melanesia and in the islands of New Guinea, we find a tradition of a man who, after a number of very curious adventures, is forced into a pit and, in order to escape therefrom, makes a chain of arrows (in exactly the same way as in the sky and in the sun myths) extending up to the top of the tree; and, eventually, he succeeds in crawling out of the pit and reaching the top of the tree by this means. This story goes on that the enemy who caused him to fall into that pit takes an arrow and shoots at his ear and, hitting it, shoots off one-half of it, and by some original process the ear is made whole again, etc. It might seem very probable that a tradition of this sort is very closely and intimately associated with the solar myths of America to which I have referred before—that, actually, we have here the falling into the pit again representing the sunset; the disappearance of the sun in the darkness; the chain of arrows, the rays of the sun in the morning extending from the horizon up to the sky; and the increase and decrease in the ear of the myth might be interpreted as the waning of the moon. It would seem to be quite natural.

In another form we have a very close analogy to the tradition which does not mention explicitly the stars, the sun and the moon, but which refers to peculiarly human and animal heroes, and tells the story which, however, we know, occurs in other legends as a solar myth.

I desire to consider the probability of an explanation of traditions of this character. In a great many cases, the similarity between the two events (not quite between the two classes of myths) is not quite so close as we have it here; but we find a great many cases in which the incidents, and the adventures related in the incidents, really remain very much different from the solar myths, and we are likely confronted with the theory by which the various kinds of tales in a great many traditions are explained as survivals of old myths of nature, or, more particularly, of myths referring to the sun, the moon, and to the seasons. This whole question is evidently very closely associated with the vexed question of dissemination and independent origin. If we assume that these traditions, where we find them, are of independent origin, then we will be justified in assuming that the development is largely that originally they were sun myths, and that the old relation has been forgotten and that, finally, it centers on a certain human, or animal, hero. If, on the other hand, we are not inclined to consider dissemination as an important element in the development of mythologies, we shall be more inclined to interpret similar myths in different manners, in accordance with the peculiar physical environment of the tribes among whom they are found.

Some Indian tribes believe that the arrow man is invisible spirits got into animals. This belief is embodied in a great number of traditions, for instance, a monster harries a house every night; it is finally discovered and shot by the owner of the house; it escapes, and he pursues it. Finally he reaches the village in which the monster is living. All the medicine men belonging to the tribe of the monster are trying in vain to discover it. Finally he is advised to make an attempt, and he feathers the arrow, which is invisible to the monster. This is analogous to bodily sickness which is invisible to the medicine man. In the islands between Japan and New Guinea the same idea prevails. It is one embraced in a tradition that a young man went out fishing, he had a bite, but lost the fish through a broken line; he dove beneath to the bottom of the sea; there he found open country; he saw a village, and entered one of the houses. Soon a girl came out and told him that the arrow-mother was sick, and that the medicine man was unable to discover the cause of the sickness. He was asked to come in, and discovered his hook, which he took out, and thus cured the sick person.

Here we have the same idea existing in two widely separated regions. We think this idea is fully explained by the organization of the human mind, which develops the idea that sickness is a material object which enters the body, and which must be removed in order to recover health. The second idea is that the law of nature is anthropomorphic and is divided into two social principles, which differ so much in social organization that what is natural to one group is supernatural to the other group. On the other hand, the theory of dissemination is not compatible with this explanation. While enjoying the correctness of the preceding theory, it adds that the possible development of ideas in distinct regions, and uninfluenced by foreign elements, when based on mental organization—sense experience alone—may take distinct courses. In many cases these may coincide; and they will be more likely to coincide, the more general the ideas in question. The great uniformity, however, which is found over extensive areas, requires the additional consideration of the influence which the contents of the mind exert upon the mode of thought. That is to say, the theory of dissemination is not, by any means, opposed to the theory of common origin and independent origin, but merely supplements the former by the addition of a new element, the relative importance of which will be great or small as the case may be. The analogy between the few cases from the Pacific islands and from America is certainly striking.

In the solution of the question it seems better to confine ourselves, first of all, to a consideration of the myths belonging to an area that partakes of the same degree of culture. It is likely that the more or less identical myths of the neighboring tribes develop on account of the peculiar organization of the human mind and the influence of the same geographical environment, and under the stress of the same social conditions; but it may also be that it would be better to assume that these ideas were borrowed and disseminated from time to time. It seems to me that the theory of independent origin, in disregarding the influence of the contents of the mind, excludes one of the most potent elements that tend to form human thought: the theory of independent origin practically presupposes that, sub-consciously at least, the minds constituting each social condition develop the same ideas alone. The consideration of the manner in which our own thoughts develop will show that this point is not well taken. The aspect in which nature appears to us is by no means the outcome of individual intellectual action: it accompanies the thoughts and teachings of our great scientists and our great philosophers, which may never have been clearly preconsidered knowledge. We all have a rather clear notion of the aspect of the world, in which we consider all matter as consisting of molecules and atoms. We have a rather clear idea of the position of the earth in the solar system and of the solar system in the universe; many of us have, also, more or less clear notions of the definition under which this aspect of nature holds good—in what way this picture of the world has been an outcome of our sense experience; but if it is an out come of our own thought under the conditions of civilization, is it not much more the point of view which we imbibe through the teaching that we receive as children, with the thoughts that are brought to our attention daily and hourly by the words that we hear and by the objects that we see? These concepts are not the results of our own judgments but the results of a long-continued series of judgments made by others, which are imposed upon us by our surroundings, and which constitute the contents of our minds with which we profit. Is this not the reason why a great genius oversteps the limits of his time to a certain extent? Judging, therefore, from the complex condition of our own civilization, it would seem apparent that the contents of the mind are the most powerful influences in shaping its beliefs.

Any one will recognize that similar conditions to those under which our views originate prevailed in the life of primitive man. The child was brought up in the social surroundings of his tribe; the thoughts of his elders were impressed by words and actions, and formed the body of knowledge which, without being the result of personal experience, affects his whole mode of thought, forming the material from which he forms his judgment. Through contact with the neighboring tribes, new elements are added to this mass of traditional judgments, which are the more readily assimilated, the more closely they are akin to those that inhere in the tribe. This, I believe, is the humanistic dissemination; and this is the reason why the theory of independent origin does not adequately represent the development of the ideas of primitive man. When we accept this theory, we conclude that it would be rash to interpret traditions—myths—which in many of the elements are similar to sun myths, as the general form of sun myths. It would seem much more likely that the forms of thought expressed in the existence of the sun myths are ever ready in the minds of the natives and lend themselves to the new combinations wherever stimulus to such combinations may be given. The idea of the chain of arrows, once being given, will suggest the introduction of a similar motive in tales of a quite distinct significance from the sun myth; and the case of the sister, which I mentioned before, may belong originally to the sun myth, or it may be introduced into this group of tales owing to its being ever present in the mind of man.

These considerations lead us to the following theory of the origin of sun myths and of the allied myths referring to the organization of the world. The problem of the world has occupied the attention of man in all parts of the globe. The myths are evidences of his attempts to solve this problem; the significance of the sky with the stars, the meeting of the heavenly bodies and the earth, the wide ocean and inaccessible underworld, are problems which have stimulated the thoughts of philosophers. Wherever man lives, observation has led to the same results, to a certain extent—the division of the world into the higher and lower strata in their world-wide occurrence. It seems very likely that we must conceive the philosophy of primitive people as the products of the thoughts of their great men. These may be medicine men, endued with more power from within than others, or thinkers whose attention is concentrated on the great problems of existence. The operations of their thought move not according to the laws of logic; but their conclusions turn upon the contents of their minds with which they operate. Thus the setting of traditions and beliefs must enter into the conclusions reached by the primitive philosopher. The social organization, his mode of life, his knowledge of the habits of animals, his knowledge of the astronomical phenomena, and his myths—information on all these subjects will enter into the system of his philosophy. If we consider the American sun myths and related myths from this point of view, we conclude that the myths, as such, cannot be interpreted purely as an attempt at the explanation of natural phenomena. We shall hesitate to explain one part of the myth as symbolizing the sunrise; another story, sunset; and still another, as the turning around of the sun from winter to midsummer; but we shall rather be inclined to consider quite a large number of the sun myths, not as belonging to ideas that refer to the sun, but rather as belonging to the body of floating beliefs. The philosophical basis of the sun myths we should rather expect to find in the clearly expressed notions regarding the sun that enter into mythology; and we shall not be surprised to find conflicting notions in different groups of myths. Such we may expect, owing to the fundamental concepts in the thought of the people as affected by the intrusion of foreign ideas and other influences.

* An address delivered at Yale University, before the American Folk-Lore Society, by Franz Boas, Ph D., of Columbia University, member of the American Academy of Science.

SIBERIAN COAL.

Coal is met with in abundance in almost every direction in Siberia, west and east as well as along the Trans-Siberian Railway itself, of poor quality, however, and so far comparatively little worked. The British commercial agent in Russia states that the beds of the Ekibastuz, Sudjenka, and Kuznetz region could supply both Siberia and the Ural, so much in need of fuel, with tens of millions of poods annually (the Russian pood = 36 lb. avoirdupois). Its inferior quality, of use however to metallurgical works, would be somewhat compensated by its cheapness and accessibility. Coal exists in the Kuznetz, the Ekibastuz, the Kirghis Steppes, the Akmolinsk and Semipolatinsk territories, the latter remarkably rich in reserves, in Eastern Siberia from the Yenisei, Krasnoyarsk, and Irkutch districts, along the Lena to the Far East, as well as in the island of Sakhalin, while even along the main line near the stations of Sudjenka, Teheremkhovo, and Misovoi, seams of more than average quality have been discovered. The Ekibastuz beds especially, in the neighborhood of Pavlodar, on the Irtish, flowing

to the railway from the south, have an almost unlimited reserve, estimated to contain a supply capacity of some 200,000,000,000 poods (3,214,000,000 tons), though the quality is anything but first rate. However moderate the quality, the supplies there are simply unlimited, but insufficiently and even primitively worked as yet, capital and far larger enterprise being needed to fully develop them; but with the increasing communications and growing necessities they are now attracting widespread attention, as on this fuel question largely depends the future of the railway, mineral, metallurgic, and, indeed, of all the industries of Siberia generally.—Journal of the Society of Arts.

[Continued from SUPPLEMENT, No. 1293, page 20733.]

AMERICAN ENGINEERING COMPETITION.*

XIV. TRANSIT AND COMMUNICATION.

THERE are a few other things to be considered in studying the question of international trade competition besides raw material, cheap labor, and low freights. No doubt the conveyance of goods is a most important factor in the problem, but hardly less important, though often overlooked, is the transportation of passengers, both on long and on short journeys. In some things English railways are superior to those of other countries, but of these it is not my intention to write. The object of these articles is to point out circumstances in which this country is deficient, or at any rate from which we can learn useful lessons from abroad. Were it otherwise, I might correct some fallacies as to the superiority of the American system of checking baggage, and point out the delays and annoyances incidental to the red-tape procedure of the United States. I might also say something as to the shortcomings of American express companies.

If the English railways have points of advantage, I am afraid the same can hardly be said of our street passenger traffic—putting aside the hansom cab, certainly a very big exception. The American street car is so greatly superior to our omnibus and tramcar that comparison is hardly possible. That is due to the greater progress in America than in Great Britain of electric traction, and that in turn appears to be largely owing to our, possibly, well-intentioned but injudicious and hampering legislation. However that may be, the Americans have hundreds of miles of electric railways to our tens, and many of the lines in this country are feeble and ill equipped compared to the powerful installations of America. In 1899 there were about 15,000 miles of electric railway track, and about 40,000 electric cars running, in the United States. At the same time in England we probably did not have 300 miles of line in operation. Wherever one goes in the more settled States, and also in many parts of those not thickly populated, as one approaches a town of any size, there are the electric railways radiating for miles out into the surrounding districts. They run along the main street of the cities and out into the country over roads hardly formed, across fields, upon narrow ledges scarped out of precipitous hillsides (as at Pittsburg), up banks so steep as to be inaccessible to horse traction, over slender viaducts and river bridges—in fact, they are covering the country with a net-work of communication that is making more rapid change in social and economic conditions than has been witnessed since the introduction of the steam locomotive.

Inside the cities the influence of electric traction is as fully marked. The cars go everywhere. A man wants to settle some business, to see his lawyer or his doctor a mile or two away. He finds out by telephone whether the person is at home and then steps outside, probably finding a car passing his door that will take him where he wishes to go, or, at any rate, close by. The great thing, however, is that when he is in the car he knows it will keep going at a good speed, he will cover the mile out and the mile back in ten minutes or so, except in a very crowded thoroughfare, like Broadway, New York. Let any one compare this with what happens in London, where omnibuses crawl from one stopping place to another; while the drivers and conductors exert all their ingenuity to baffle the police in the endeavor to keep them moving. A few days ago I took an omnibus near the west end of the Strand to go to Westminster. During the seven minutes it took us to cover less than a quarter of a mile—stopping and dawdling all the time—we were pushing the whole of the overtaking vehicles out into the middle of the street where they checked the eastbound traffic; in fact, this omnibus practically took up double its width of the narrowest and most crowded part of the Strand for a considerable space of time.

When people talk of the impossibility of running electric cars in the narrow and crooked streets of London I do not think they take time into account. An electric car, like one of the fine cars of Cleveland, Ohio, having doors at each end and a door in the middle (a point of great importance for rapid filling and emptying), would clear fifty people out of the crowded end of the Strand in one minute, while it took my omnibus, with a capacity of half that number, seven minutes to get clear. Most of the important quick traffic in London is done in hansom cabs, and if we compare the amount of obstruction caused or the area occupied by a passenger in a tramcar with one in a hansom cab the difference is very striking. Certainly it would be impossible to run a street railway service through the Strand under present conditions; but it must be remembered in considering this question generally that cabs and omnibuses would disappear as soon as electric traction made its appearance, and much of the heavy traffic might be excluded within certain hours from some of the more crowded places without undue hardship to any one; while undoubtedly some corners would need rounding off. In America the custom is common of sending cars proceeding in opposite directions down different parallel streets. Thus east-bound traffic might go down the Strand, Fleet Street, and Ludgate Hill, and west-bound traffic along the Embankment and Queen Victoria Street. The suggestion seems preposterous to Londoners; perhaps it is. I am not proposing a remedy, I am only drawing a parallel. An American business man who knows London almost as well as New York recently said to me: "I can't understand how you folks in England do business at all. If our telephone and street car system were like yours, half of us would have to quit work to-morrow."

The ancient city of Boston, Mass., affords one parallel to our narrow, crowded London streets; and here the Americans have solved the problem of quick traffic in a very effective way. The electric cars run out on the street railways to and from all parts of the surrounding country in the usual manner, but when they get to the heart of the city the lines dive underground and follow the course of the streets just below the surface. It is as if lines ran from Dorking, Reigate and Guildford, meeting in the Lambeth Road, and proceeded across Westminster Bridge to Whitehall. Here there would be a descent into a tunnel, which would take the line of the Strand, Fleet Street, etc., meeting other tunnels at various important points and with frequent stations. It is the completeness of the intercommunication in Boston that makes this system so successful. The cars run singly, not in trains, and follow each other up in the stations so quickly as to be almost touching. The junctions are so arranged that the passenger can "transfer" to get from any one part to any other part, and seldom is there a wait of more than a minute or two. The tunnels are brilliantly lighted throughout and the stations are well planned, so that the arrival platform for one line is, on its opposite side, the departure platform for another. These tunnels (or rather covered ways, for they have been constructed on the cut and cover principle) being only just beneath the surface, the platforms are approached by very few steps. It may be that the old difficulty of gas and water pipes would prevent any scheme of this sort from paying in London; but if it is really impossible to introduce mechanical traction into our big centers of industry, we must settle down to the conviction that American merchants and manufacturers have a trump card we cannot meet in the great game of international trade competition.

The Bostonians are not only burrowing underground, but are extending upward with their traffic facilities. They have under construction at the time of writing an overhead railway like those in New York. The dock-side overheard railway, of Liverpool, is a somewhat similar structure. It would need a bold man to suggest such an unsightly erection for London; but, come what may, people must get about or business comes to a standstill. It may be that some day the foot pavements, or sidewalks, as the Americans call them, will be carried on steel galleries in our most crowded thoroughfares, so that the street surface will be left entirely to vehicular traffic. In that case, first-floor windows would become shop-fronts; unless the stores system grows to the extinction of separate shops—an event which will not come to pass, at any rate, for a good many years in England, though "department stores" are growing in size and number with wonderful rapidity in America. In any case the overhead railway is such a disfiguring thing that it is to be hoped it will never be forced upon us in this country.

The way in which business breeds business is seen plainly in a rapidly developing country, and never did any country develop so quickly as the United States has within the last three years.

I have already described the works of the E. P. Allis Company, at Milwaukee—they had over six million dollars' worth of orders on their books at the time of my visit—and it will give some further idea of the increase of transit facilities in America if a few details are stated respecting the Westinghouse Electric Company's works; it being understood that they do not by any means stand alone in this industry. There are made here forty motors for street cars a day, besides a large number of electric generators and motors constructed for factory purposes and electric lighting. When the Westinghouse Works were transferred to East Pittsburg, about five years ago, the volume of business done was considerable, about 2,500 operatives being employed. At the time of my visit there were over 5,000 at work in the electrical factory alone. Besides this there were in the engine shops 1,500 men, and in the railway brake works 2,500 men. It was thought at the time of the removal that the new works would be large enough to allow the business to be doubled without a further extension. The main shop of the electric works was 754 feet in length and 231 feet wide. Along each side of the floor ran galleries for the lighter tools, each 80 feet wide. That, it will be seen, would form a very big factory in itself; but since then another 194 feet has been added, and still the work has so increased that a further length of 268 feet was in progress last October, and will doubtless be well on toward completion before this article appears. The other buildings, such as forge, smiths' shops, etc., have been increased in proportion. I saw in progress 5,000 horse power electrical generators, which I think are the largest machines of the kind ever made. Some of these were for the St. Lawrence Construction Company, a power-distributing venture on the same lines as the Niagara power scheme, where there are several of these 5,000 horse power generators. What is more to the present purpose there were sixteen generators, each of 4,000 horse power capacity, in course of construction for the Third Avenue Railroad, New York. This is a city line extending sixteen miles from the post office, which is in the heart of the business quarter of New York. The power house is at the extremity of the line. Not very long ago it would have been commercially impossible to transmit so much electric energy over this great distance. It is satisfactory to know that some of the motors in these works are supplied with current from dynamos driven by the Parsons Steam Turbine, a great mechanical invention which British engineers may fairly be proud to see in America, as it is the work of one of their number.

There are other electrical works of enormous capacity. The General Electric Company, for instance, have a truly wonderful establishment at Schenectady, but, much to my regret, I was not able to visit it.

For street railway work the "single-car unit" is desirable, although in Chicago one sees trains of three cars passing through the streets. I think I have seen four. The overhead railway has been erected there also, and in connection with the South Side Elevated Railroad there has been introduced a new system of operating trains, which seems likely to lead to important results. This is known as "the multiple unit system," and is the invention of Mr. Frank J. Sprague, who was, I believe, the first to design a commercially successful electric street railway. For railways proper (as opposed to street railways) having a regular scheduled service of trains the single car running independently is evidently not so advantageous as the multiple unit or a coupled train of cars. With the steam locomotives long trains can be hauled, because the great weight of boiler and engine gives plenty of adhesion to the driving wheels. The electric motor, on the other hand, is comparatively a light thing, and, though the power may be ample, its wheels lack adhesion to drag a long train. It is, therefore, desirable that each car should carry its own motor, so as to utilize the weight of the car itself and of the passengers to give adhesion. The objection to this formerly was that a motorman was needed on each car. Mr. Sprague has, however, devised a system by which a number of cars can be operated from the platform of any one of them. At Chicago I saw a photograph of a 13-car train operated in this way.

At the central station of the line I was told that the cost for power was rather less than five mills (about a farthing) per kilowatt hour. The generating machines are run day and night, storage batteries being used to equalize the load. A comparison of the steam locomotive and electric traction systems has been made from data collected from the working of the South Side Railway, and the ratio of expenses to earnings was 87·3 for steam, as compared to 57·3 for electricity.

Mr. Sprague, speaking from an engineering point of view, told me he was convinced the time had come for electric traction to be adopted for all suburban traffic around London. Making every allowance for the engineering parallel of the fondness of the shoemaker for leather, the opinion is worthy of all consideration and respect. It is difficult to imagine the Southwestern, the Great Eastern or other lines, which run both long distance and suburban trains, having a mixed steam and electric service, but in America this has already been done. In Connecticut I traveled several miles in an electric car run on the main lines intermediately with the regular steam-drawn trains. It is a rather startling thing at first to see these single cars rushing along the ordinary railroad at high speed with no visible means of propulsion. A third-rail is laid between the two ordinary wheel rails, and this acts as a conductor for the electric current, which is picked up and taken to the motor on the car by suitable mechanism. The system, I understand, has worked very successfully, and, in spite of one or two drawbacks, is considered highly promising. To a cautious Englishman one of the most striking of the drawbacks is that the naked conductor is laid at the ground level and the tension of current is high. Now, American railways are hardly fenced at all, and grade crossings are frequent. It is a little unsettling to see children playing on the side of the track, and also using it as a thoroughfare to and from school, after the manner of American children all over the Union. I did not hear that any serious mishaps had occurred; but, as a railway official said, "The management does not try to get such things into the papers." I did hear, however, that on the previous day a man had received a severe shock; with what ultimate result did not seem to be a matter to excite curiosity, as he was only an Italian. Besides, he was much blamed for having iron nails in his boots. The Americans hold the view that if a man has not sense enough to keep clear of a third-rail, the United States has no use for him. Our Board of Trade principles are not popular there.

On the subject of passenger traffic on trunk railroads much has been written in the past and more yet remains to be said; but it need not be said here, because the conditions to be met in the two countries, Great Britain and the United States, are so different that there must necessarily be differences in practice. He would, however, be a very prejudiced or very patriotic Englishman (both names are often applied to the same thing) who would deny that in some respects the Americans have beaten us in railway practice. For this again there are reasons. The early American engineers had the advantage of our experience; they followed and were able to avoid our errors. Thus, they have not tunnels and station platforms that prevent their running larger coaches. That is one most important matter in regard to the comfort and appearance of the interiors in which we cannot compete unless the railway companies of the kingdom are prepared to spend a sum so vast that it is beyond contemplation. As to the much discussed question of the superiority or otherwise of the English coaches with compartments, as against the American car with its central aisle, all one can say is every man to his humor. But this, I think, can hardly be said of women, too; for as far as my experience goes, they prefer the big open car to the privacy, so much prized by some, of the English carriage. The long journeys which have to be taken in America render it necessary that there should be more elaborate provision for the comfort of passengers, and the more rigorous winters make the warming of trains a matter that cannot be neglected. In the important trains on our best lines sleeping accommodation is very good, but in the matter of heating we are wofully behind, although some efforts have been made in this direction of late. It is difficult for an Englishman to understand the feeling of an American arriving for the first time in England in winter, and having to make a railway journey by any train other than a London express. The dreary waiting rooms, the dingy, cell-like compartments, the long tunnels, often to be passed through in unlighted carriages, and, above all, the damp, biting cold, all serve to strike terror to the souls of the delicately-nurtured men and women of the United States; though it may be these things serve a useful purpose in hardening the Briton.

That, however, cannot be said of another characteristic of some English railways, their unpunctuality. American trains are not invariably punctual, but they are far more to be depended upon to keep time than are our own. And yet the Americans haul some heavy trains. The Pennsylvania Railroad, which is the premier line of the United States (and I am almost tempted to say the best managed line in the world) runs the express between New York and Chicago with, I understand, almost undeviating punctuality. It may consist of eight cars, weighing alone—without passengers or luggage—about 360 tons. The speed of the Chicago

* This series of articles on American Industries was written by an expert of The London Times, who made an extensive trip through this country in order to prepare the articles, the first of the series being published in the SUPPLEMENT of July 21.

express trains will average between 44 and 50 miles per hour on the section between Jersey City and Philadelphia, but the weight is not always so great as that given. Another celebrated train on the Pennsylvania system is the Congressional Limited, which generally consists of six cars weighing, empty, about 312 tons; and which on the 227 miles between Jersey City and Washington will average 46 to 47½ miles an hour. Perhaps the most remarkable running is done between Philadelphia—or rather Camden, which is to Philadelphia what Birkenhead is to Liverpool, but with the Delaware in place of the Mersey—and Atlantic City, a seaside "resort." The scheduled time for the run between these points, 58·3 miles, is 55 minutes. This service illustrates the stimulating effect of competition, for the Philadelphia and Reading have an almost similar train. On occasions, however, the scheduled time has been greatly exceeded. For instance, on July 31 last the running time was 50½ minutes, or at a speed of 69·3 miles an hour for the whole distance. On that occasion there were eight cars, in themselves weighing 236 tons, besides which there were 369 passengers. On this run the distance between Winslow Junction and Drawbridge, 30·6 miles, was accomplished in 22½ minutes, or at the rate of 81·6 miles an hour, and that between Winslow Junction and Absecon, 24·9 miles, in 18 minutes, or at the rate of 83 miles an hour. On September 22 last they made a speed of 93·5 miles an hour for 18·7 miles, but this was with a lighter load, having only five coaches and 152 passengers. On the latter run a speed of 93 miles an hour was made for 16 miles, and 93 miles for 10 miles. There was, however, evidently a check, as the total average time was only at the rate of 67·2 miles an hour. The engine that draws this train has two pairs of driving wheels each 80 inches in diameter, a leading four-wheel bogie, and a pair of trailers. The cylinders are 20½ inches diameter by 26 inches stroke. The steam pressure is 185 pounds per square inch. The grate area is no less than 69⅕ square feet. The heating surface of the tubes alone is 2,102 square feet, in addition to which there is the surface of the fire box, which is of unusually large dimensions.

The passenger stock of the American railways is no less interesting than the locomotives. The system upon which the railroad companies work, in conjunction with car-owning firms, is well known in this country in connection with the name of Pullman.

In many respects Pullman, near Chicago, is one of the most interesting places in America. It is as a whole—the works and the town—a curious mixture of the practical and the ideal. The late Mr. Pullman was a man of remarkable business capacity. Having amassed a very handsome fortune, and holding the destinies of a large number of people in his hands, he essayed to make them happy by compelling them to be good. Like most strong men and earnest workers in this direction he raised up a good many opponents, and his motives were often misunderstood or willfully misrepresented. No doubt if he had simply gone his way and let his workpeople go theirs, without bothering himself about their morals and domestic affairs, he would have had less worry during his life and fewer detractors after his death.

I spent a considerable time at Pullman and accumulated material enough to write a treatise on car building; but it only bears indirectly on the engineering competition of the United States. Yet, though the bearing may be indirect, it is not trivial. It may seem at first glance a small matter industrially whether passengers are carried more or less comfortably from town to town and city to city. That, I venture to say, is a superficial view. The business success of Americans is largely—very largely—due to the enormous extent to which they move about. I imagine a Chicago merchant thinks less of the thousand-mile run to New York than a Londoner does of two hundred miles to Liverpool or Manchester. The Pullman Company have had not a little to do with all this, and they are still working on the same lines as vigorously as ever. In October, 1899, they employed 7,152 persons, of whom only 2,906 were native Americans.

Next to the magnitude of the operations here I think the feature that impressed itself upon me most was the beauty and sterling value of the decorative work done. The money that is spent on interior decoration appears more than lavish. I questioned—as I had before in British shipyards where Atlantic liners are built—whether all this expenditure on ornamentation was not excessive and wasteful. "Would not passengers rather pay less and have less magnificent surroundings?" The answer was conclusive in vindicating the policy of the Pullman Company. "We exist," they said, "on the preference of the public for costly and artistic surroundings while traveling. The more beautiful and the more comfortable we make our cars, the more successful we are in our ultimate aim—a good balance-sheet." But beyond this, I think it may be said that there is an economic side to this luxurious traveling. For instance, a business man may feel he ought to make a two or three hundred mile run, but, under the old conditions, he would shirk the dreary monotony of the journey.

Tomato Leaves to Keep off Insects.—On an Australian farm the fact has been observed that tomato leaves have the property of driving away insects. The odor of these leaves is evidently highly repugnant to insects, for not only were all flies and creeping animals kept off from a bed of plants, by covering it with tomato leaves, but it was even sufficient to sprinkle the plants with a decoction of tomato flowers in order to rid them permanently of insects of all sorts. This medium is also said to be excellent for keeping away flies from horse stables.—Technische Notizen.

Pitch Dissolves Iron.—According to J Brand, pitch dissolves metallic iron. At first a faintly-colored protoxide salt of the resinic acids forms with generation of hydrogen, changing, by the action of the air, into a dark oxide salt. Pale colophony is capable of absorbing 0·9 per cent. of iron under the influence of a temperature of 180° to 200° C. Pitch containing iron cannot, however, give off any iron to beer, for which reason the fear that beer might taste of iron through pitch is groundless.—Zeitschrift für Nahrungs- und Genussmittel.

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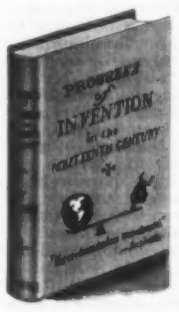

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